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88-1904

IN THE

Supreme Court of the United States

OCTOBER TERM, 1988

IN RE: OHIO RIVER DISASTER LITIGATION

IN THE MATTER OF THE COMPLAINT OF WALKER TOWING CORPORATION CONSOLIDATED WITH IN THE MATTER OF THE PETITION OF B-R RIVER SERVICES, INC.,
Petitioners,

VS.

UNITED STATES OF AMERICA,
Respondent.

APPENDIX TO JOINT PETITION FOR WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE SIXTH CIRCUIT

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APPENDIX

UNITED STATES COURT OF APPEALS
FOR THE SIXTH CIRCUIT

Nos. 85-3990; 85-4036; 86-3216

In re: Ohio River Disaster Litigation

Complaint of Walker Towing Corporation;
Petition of B-R River Services, Inc.,
Plaintiffs-Appellees,
Plaintiffs-Appellants (86-3216),

B-R River Services, Inc.,
Cross-Appellant (85-4036),

v.

United States of America,
Defendant-Appellant (85-3990),
Cross-Appellee.

On Appeal from the United States District Court
for the Southern District of Ohio.

Decided and Filed December 5, 1988

Before: MERRITT and RYAN, Circuit Judges; and PECK, Senior Circuit Judge.

MERRITT, Circuit Judge. This admiralty case against the government arises because plaintiffs' barges were damaged as a result of the allegedly negligent operation of a navigational dam along the Ohio River near Cincinnati by the United States Army Corps of Engineers during a prolonged period of cold weather and ice formation. Our decision turns on two interlocking questions: whether controversial decisions made in connection with the operation of Markland Dam by the Corps are covered by the "discretionary function" exception to governmental liability under the Federal Tort Claims Act, and whether any conduct by

the Corps not covered by this exception was negligent and caused an ice "jam" or "gorge" to form which damaged petitioner's barges. The District Court concluded that the discretionary function exception was inapplicable and that the Corps' negligence caused an ice jam to form, in turn causing barges to sink or be swept downstream against Markland Dam. It awarded $2,711,649.50 to plaintiffs as damages, plus prejudgment interest.

Petitioners Walker Towing Corporation and B-R River Services sought indemnity from the United States under the Suits in Admiralty Act, 46 U.S.C. §§ 741-52, for damages sustained by them and their shippers as a result of the January 1978 disaster. The case was tried to the District Court. On September 24, 1985, the District Court filed a 136-page opinion and order concluding that the Corps was negligent in several aspects of the operation of its facilities, that the negligence, and not an unavoidable "Act of God," was the actual and proximate cause of the plaintiffs' damages, that the Corps was not entitled to immunity under the discretionary function exception of 28 U.S.C. § 2680(a), and that the plaintiffs thus were entitled to recover from the government. We conclude that the major decisions by the Corps which plaintiffs claim negligently caused their injury are protected by the discretionary function exception. Therefore, we reverse the judgment of the District Court.

I. BACKGROUND

A. The Dam Structure

The Corps has divided the Ohio River into three operating districts: Pittsburgh, Huntington, and Louisville. There are two dams involved in this case: Meldahl, which is in the Huntington District; and Markland, in the Louisville District. Meldahl is located at mile 436.2; Markland is located downstream at mile 531.5. Meldahl is 35 miles above Cincinnati; Markland is 61 miles below Cincinnati. In Corps parlance, the "Meldahl pool"

is the portion of the river upstream from Meldahl Dam, the "Markland pool" is the portion upstream from Markland to Meldahl, and the "McAlpine pool" is the portion upstream from McAlpine Dam at Louisville to Markland.

Meldahl and Markland are both navigational dams. River traffic passes the dam by way of navigational locks. Markland, the site of the problem in this case, consists of two locks on the south (Kentucky) side of the river and twelve water control gates, called "tainter gates," that span the entire river. The locks and dam structure is approximately 1500 feet wide. Each of the twelve tainter gates is 100 feet wide and 42 feet high. The locks are capable of raising or lowering tows of up to 15 barges and a towboat a distance of 35 feet. In addition to the locks and dam structure, Markland includes a hydroelectric plant on the Indiana side of the river that services part of southern Indiana.

When Markland was built in late 1950's and early 1960's, the Corps was concerned with potential problems in passing accumulations of ice and drift through the dam. As a solution, the Corps installed tainter gates at Markland that could be submerged as well as raised. When a gate is raised, there is a gap between the river bed and the bottom of the gate; water passes under the gate. Some ice and drift can be passed under a raised gate because the effect of raising a gate is to create suction which would pull ice and drift from the surface underneath the gate and through the dam. In theory, however, it is much easier to pass ice and drift over a submerged gate. When a gate is submerged, ice and drift simply flow over the gate; much less force—and thus less water volume—are required to pull ice and drift over a submerged gate than under a raised gate. Five of the twelve gates at Markland are of the submergible type. Submergible gates can also be operated in the raised position; they are thus two-way devices.

By the middle of 1964, the Corps encountered significant problems in operating submergible gates at some other dams on the Ohio. When the submergible gates were lowered, they had a

tendency to vibrate. Although the Court found that the vibration problem at Markland was not significant, dam personnel were not permitted to operate the gates in the submerged position at any of the Corps' dams on the Ohio. Therefore, in 1978, the only way to pass ice at Markland using tainter gates was by raising them. The District Court found that the gates must be raised at least 10-12 feet off their sills, which are at the bottom of the river, before enough suction could be generated to pass ice under the gates. Additionally, the Court found that at least two adjacent gates must be raised before the suction is great enough to pass ice. Thus, ice could be passed using the gates only when the flow of the river was great enough that two gates could be raised without causing the level of the pool to fall below navigable levels. Generally, according to the witnesses and the District Court's findings, one foot of gate opening on one 100-foot wide gate passes 3,000 to 5,000 cubic feet per second (cfs). (Gate opening is measured by the total number of feet all gates are raised. E.g., if all twelve gates are raised one foot each, the dam is "running" twelve feet of gate opening.)

Other problems in passing ice also presented themselves. The Corps had determined that the concentration of all flows on two adjacent gates could cause riverbed erosion ("scour") immediately downstream of the dam unless the downstream pool was deep enough to alleviate the problem; otherwise, river flows had to be high enough that all gates could be raised. Additionally, the hydroelectric plant created ice-passing difficulties. The plant's full capacity was a flow of 35,000 cfs. The Markland lockmaster testified that the plant was routinely operated at full capacity. Flow used for the hydroelectric plant could not be used to allow the raising of gates; therefore, the 35,000 cfs used by the hydroelectric plant represented seven to twelve feet of gate opening that was unavailable.

The other ice-passsing mechanism at Markland was the lock system. Markland has both a main and an auxiliary lock. The auxiliary lock, which is half as long as the main lock, is closest

to the Kentucky shore; the main lock lies next to the auxiliary lock. The locks operate by means of "mitre gates," which swing out from the walls of the lock to allow filling or emptying, and swing back into the walls to allow vessels to enter and leave the lock. Additionally, each lock is equipped with one-piece "emergency leaves," which lift out of a recess built into the river bed. Ice can be passed through a lock by raising an emergency leaf to a level just below that of the upstream pool and allowing water and ice to flow over the leaf, thus "skimming ice." Due to a design problem, it was impractical to use the main chamber emergency leaf at Markland for passing ice. The auxiliary chamber could have been used; however, in 1976 a latch pin esential for use of the auxiliary chamber emergency leaf broke. The pin was not replaced until January 19, 1978. In any event, the Corps had permitted a "pusher boat" to become frozen in the chamber, thus eliminating the auxiliary lock from use as an ice-passing device.

B. January 1978

The District Court's opinion gives a detailed, day-by-day account of weather forecasts and conditions, river flows and conditions, and Corps actions leading up to January 27, 1978. We need not recount all of that history here. Instead, we summarize only the facts relevant to our decision.

One of the sources relied upon by the District Court is the Corps' Ice Committee Report of June 1978 (Exhibit 179). An excerpt from that report provides a concise summary of the events that ultimately led to this litigation:

> Tributary storage reservoirs had been effective in averting moderate flooding in several principal Ohio River tributaries during December. Much of the excess reservoir storage had been released and streamflows were approaching "normal" by the end of the month. However, below normal temperatures had begun to produce ice, par-

ticularly on tributaries. The continued development of ice both on tributaries and along the banks of the Ohio on into January would have to be considered normal for that time of year.

During 7-9 January a strong frontal system passed over the Ohio basin. Runoff producing rainfall was accompanied by rapidly falling temperatures which then produced snow. This began the accumulation of snow cover which was to ultimately set a record for the winter over much of the basin. It also signaled the advent of much colder temperatures which were to prevail for an extended period. More significantly, however, runoff from the rainfall set in motion much of the ice which was to later become such a problem. Runoff from uncontrolled areas below tributary storage reservoirs flushed substantial volumes of tributary ice out into the Ohio, where rising stages broke bank ice to join the overall mass. . . .

In the middle reaches of the Ohio, streamflow increased threefold from the morning of 7 January until the morning of 12 January. Movement of ice resulted in progressively worsening conditions, and from evening of 16 January until morning of the 17th, no tows were able to get through the ice pack above Meldahl Dam. Thereafter, movement of boats and ice gradually reduced the congestion at Meldahl but the queue of waiting boats was not cleared until the 25th. All during this time, intermittent snowfall continued to add to overall coverage, but temperatures remained well below normal into the week of 22 January.

By 24 January, temperatures had risen enough that moisture moving into the basin that day fell in the form of light rain. Intensity increased only slightly in the next 24 hours but there was no evidence of runoff or increased streamflow. It appeared that the snow pack was absorbing and holding the rainfall. Weather forecasts on the morn-

ing of 25 January indicated continuation of relatively light rain for another 12-18 hours and then a return to very cold conditions. While rainfall intensity was expected to increase slightly, total amounts expected were not considered alarming. Rainfall intensity increased a great deal more during the day than had been anticipated and, by late afternoon, the rain was being forecast to turn to heavy snow by about midnight and to continue into the 26th.

Forecasts on the morning of 25 January had been based on the belief that a low pressure system in the Gulf states, associated with a warm front to the south and southeast of the Ohio basin, would pass to the southwest of the basin and up the Atlantic coast without significant impact on the Ohio basin. Coming into the western and northwestern portions of the basin was a cold front that was expected to move eastward over the basin, bringing much colder air and shutting off moisture. Later in the day, the low pressure system unexpectedly joined the cold front, intensified, and took a northeasterly path right across the Ohio basin. With record low barometric pressures, the storm passed through the Cincinnati area shortly after midnight with wind gusts reaching 50 mph. Gusts reached 80 mph by the time the storm exited the basin in the Cleveland area later in the day on the 26th.

Temperatures on the middle reaches of the Ohio plunged to around zero on the morning of 26 January and strong winds prevailed through much of the following day. Blizzard conditions paralyzed much of the area, but the most important factor relating to river ice had been the rainfall immediately preceding the enveloping cold air. In about 48 hours, rainfall intensity steadily increased from an insignificant drizzle to fairly heavy just before turning to snow. Rainfall averaged about 1½ inches over most of the southern tributaries. With overflow of storage reservoirs cut to minimum, runoff from remaining uncontrolled por-

tions of these watersheds brought rapid stream rises. The collective effects of this outpouring into the Ohio main stem were rapid rises on the main stem, and operators of the navigation structures had no alternative but to simply pass through whatever water or ice came to them from upstream.

The river stage at Cincinnati rose from 29.6 feet on the morning of 25 January to 35.3 feet by the next morning and then to 46.6 feet by the morning of the 27th. Thereafter, the rise slowed and a crest of 53.9 feet was subsequently reached on the 30th. Ice movement, with periodic stoppage and accumulation, had been a significant problem since the 16th. By the 25th, several miles of the river upstream from Markland Dam had become so jammed with ice that navigation had essentially ceased. The rapid rise beginning on the 25th and the forcing of more ice into that jam then produced a nightmare for the next several days. It is difficult to know with certainty just when the massive ice jam began to become a gorge jam causing a damming effect. Best indications are that it was late morning on the 27th, when localized flooding was reported at Aurora, Indiana. In any event, force of the rapidly increasing riverflow soon broke the gorge in the afternoon and moved much of the ice down against Markland Dam.

Exhibit 179 at App. 1, pp. 6-7.

When the ice jam described above broke, at 4:17 p.m. on January 27, a wall of ice and water swept downstream. Although the speed of the broken gorge was only four or five miles per hour, its force was sufficient to sweep away anything in its path. As the District Court described the scene:

What occurred was probably the greatest single disaster to hit the Ohio River in modern times. Barges, towboats, and docks were swept onto or through Markland Dam; barges and towboats were sunk; Big Bone Island [at mile

517] was simply shaved off, and does not now exist. Cleanup operations took weeks, and these events have earned a permanent place in Ohio River lore.

Dist.Ct. opinion at 90. Both Walker Towing and B-R River Services sustained property damage when the jam broke.

C. Ice Jams

Several experts testified regarding the formation, characteristics, and dissipation of ice on the river. A general understanding of river ice is necessary before we discuss the specifics of the January 1978 ice.

Ice can form on a river only when the water reaches maximum density, which occurs at around four degrees Celsius or 39 degrees Farenheit. At this point, the formation of ice can occur in two different ways. Sheet ice will form if there is little turbulence. The water at the surface is cooled to zero degrees Celsius (the freezing point), while water below the surface is not quite as cold. The more quickly sheet ice forms, the thinner it will be, because the ice cover will insulate the river from colder air and thus trap the heat energy in the water. Sheet ice presents relatively few problems to navigation, primarily because of the structure of sheet ice crystals. The crystals are long and thin and arranged in a vertical plane. Thus, when sheet ice is broken (*e.g.*, by a towboat), it simply fractures vertically. Once the ice is fractured, the thermal energy in the water below supplies enough heat to melt the ice.

The second way ice can form on a river, and the way the ice formed in January 1978, occurs when the water is turbulent and the air temperature is extremely cold. Turbulent water can reach a temperature slightly below the freezing point before solidifying. In this situation, most of the heat energy in the water has been dissipated. When the "supercooled" water (water in liquid form with a temperature below freezing) comes into contact with the subzero air, "frazil ice" can form. Frazil

ice crystals are small and flat, and cling to one another and anything else with which they come into contact, creating a sort of slush. Once frazil ice has formed, individual particles of frazil ice come together to form larger pieces of ice, called "brash ice." Brash ice in turn may develop into even more solid pieces of ice called "black ice."

The formation of frazil, brash, and black ice creates more serious navigational problems than the formation of sheet ice. Ice cover on the river becomes an accumulation of floes. Because the thermal energy of the water must be largely dissipated before frazil ice will form, there is less potential for melting than with sheet ice. The longer-lasting nature of this type of ice, the creation of large moving floes, and the tendency of the ice to stick to anything it touches combine to cause a variety of navigational difficulties.

If the ice floes are unobstructed, the ice will simply move downriver. If, however, something obstructs the ice, a "jam" (also called a "gorge") can form. A variety of factors can independently or in unison cause ice to be arrested. Natural obstruction can include a narrowing in the river, bends in the river, islands or shoals. Man-made obstructions such as dams can also arrest the downstream progress of ice.

Once ice is obstructed, one other set of conditions must obtain before a jam forms. If the ice simply stays in place in a single layer, the river will continue to flow underneath the ice and relatively little harm will result. However, if the velocity of the ice moving downstream is great enough, and more and more ice comes downstream, the new ice will begin to pile up underneath the ice already present, creating a damming effect—an ice jam.

Engineers have developed a mode of analysis to aid prediction of when and where jams will form. The analysis was developed to predict when logs would jam on a river, but has been adapted as a predictive tool for ice. This analysis relies on a variable

called the "Froude number." The formula for obtaining the Froude number for a given point in the river is:

$$FR = V/gY$$

where V is the velocity of the water, Y is the depth of the water, and g is the gravitational constant, 32.2 ft./sec^2. Thus, the faster and shallower the river is at a certain point, the higher the potential for jamming. According to the plaintiffs' ice expert, Samuel Lazier, a value greater than Fr = 0.08 indicates a high potential for jamming. The use of Froude numbers to predict jam formation is complicated by the further facts that upstream progression of an ice cover occurs more easily at lower Froude numbers, as does clogging of ice traveling downstream. Indeed, by the close of his testimony, Lazier acknowledged that Froude number analysis is merely an "indicator," and is not to be taken "literally." Tr. 826-27.

The development of an ice jam occurs over a period of time. New ice is constantly delivered to the jam, but the older ice is eroded somewhat by the flow of the river. Eventually, as more new ice arrives than old ice erodes, a jam reaches the point where it must either deteriorate or break. If the jam deteriorates, the ice simply continues to move downstream with the normal flow of the river. However, if the jam is large enough to cause a severe blockage of river flow, a differential head will form. A differential head is a large buildup of water on the upstream side of the jam combined with relatively little water on the downstream side. This creates a large force across the jam. The force of the differential head can be great enough to break the jam and sweep it quickly downstream, carrying anything in its path (*e.g.*, barges and towboats) with it. The technical term, derived from the French, for this rush of water and ice is, appropriately, a "debacle."

D. The District Court Decision

After a lengthy bench trial, the District Court found that the government was liable for all of Walker Towing's damages and

40% of B-R River Services' damages. The District Court summarized its holding as follows:

> For reasons which follow, we find and conclude that the United States was negligent in several aspects of its operation of facilities owned and operated by it, through the Army Corps of Engineers. The gist of the negligence findings are that the Government, under a duty to use due care in the operation of its locks and dams, breached that duty by, inter alia, failing to pass ice through Markland Locks and Dam as the ice came downstream during the middle weeks of January, 1978; failing to engage in routine surveillance of the reaches of the Ohio River upstream from Markland; failing to train its personnel in methods of handling and evaluating ice conditions; failing to ensure that the dam was in fact capable of dealing with reasonably foreseeable ice conditions; and failing to intermittently restrict diversion of river flows to a hydroelectric generating facility located on the Markland site so that ice could be passed through the dam.
>
> We also conclude that the acts or omissions detailed herein constitute deviations from the appropriate standard of care and were a proximate cause of the damages sustained by petitioners Walker Towing Company, Inc. and B-R River Services, Inc. However, we conclude that B-R River Services, Inc., was itself negligent, and attribute to that petitioner sixty percent of the responsibility for its recoverable losses.
>
> Finally, we conclude that Walker Towing Company is entitled to recover for its losses in the amount of $1,500,000.00, and B-R River Services, Inc. is entitled to recover for its losses in the amount of $711,649.50, both together with prejudgment interest at the statutory rate from the dates on which petitioners settled with their claimants.

Dist.Ct. opin. at 4-5.

II. DISCUSSION

The United States has appealed the decision of the District Court on several grounds. First, the government asserts that all of its actions are shielded from liability because all of the actions upon which liability was predicated were discretionary functions. Second, the government asserts that the Corps' handling of the ice conditions in January 1978 did not cause the breaking of the ice jam and that the District Court was clearly erroneous in so holding. Third, the government argues that the District Court held the Corps to an unreasonable standard of care. Additionally, the government asserts that even if the disaster can in some way be attributed to the actions of the Corps, the disaster was too remote a consequence of those actions to be regarded as the proximate cause of the disaster and was otherwise unforeseeable. Finally, Walker Towing cross-appeals from the District Court's denial of its request for attorneys' fees under the Equal Access to Justice Act, 28 U.S.C. § 2412. Because we hold that the District Court erred in finding that no Corps actions causally related to the disaster were shielded by the discretionary function exception, we need not reach the government's arguments on proximate cause. Additionally, we do not decide the cross-appeal because the plaintiffs are no longer prevailing parties.

A. The Discretionary Function Exception

When Congress enacted the Federal Tort Claims Act, it preserved the government's sovereign immunity for

> any claim based upon an act or omission of an employee of the Government, exercising due care, in the execution of a statute or regulation, whether or not such statute or regulation be valid, or based upon the exercise or performance or the failure to exercise or perform a discretionary function or duty on the part of a federal agency or an employee of the Government, whether or not the discretion involved be abused.

28 U.S.C. § 2680(a). We have held that the discretionary function exception applies to the Suits in Admiralty Act as well as to the FTCA. *Chotin Transp., Inc. v. United States,* 819 F.2d 1342, 1347 (6th Cir. 1987) (en banc). The question whether the discretionary function exception shields the government from liability is one of subject matter jurisdiction; therefore, we examine that issue first. *Feyers v. United States,* 749 F.2d 1222, 1225 (6th Cir. 1984); *Carlyle v. United States Department of the Army,* 674 F.2d 554, 556 (6th Cir. 1982).

In *Dalehite v. United States,* 346 U.S. 15 (1953), the Supreme Court first addressed and elaborated on the scope of the discretionary function exception. It enumerated three types of administrative activities which are covered by discretionary function: the initiation of programs, planning the operation of programs and carrying out programs in accordance with directions. In holding the government immune from liability for damages resulting from negligent drafting of fertilizer export regulations, negligence in the manufacture of fertilizer, and the negligent failure to police the shipboard loading of fertilizer, the Court held that all three types of alleged negligence were protected by the exception.

> It is unnecessary to define, apart from this case, precisely where discretion ends. It is enough to hold, as we do, that the "discretionary function or duty" that cannot form a basis for suit under the Tort Claims Act includes more than the initiation of programs or activities. It also includes determinations made by executives or administrators in establishing plans, specifications, or schedules of operations. Where there is room for policy judgment and decision there is discretion. It necessarily follows that acts of subordinates in carrying out the operations of government in accordance with official directions cannot be actionable. If it were not so, the protection of § 2680 would fail at the time it would be needed, that is, when a subordinate performs or fails to perform a causal

> step, each action or nonaction being directed by the superior, exercising, perhaps abusing, discretion.

Id. at 35-36 (footnotes omitted). The court found that government decisions on which the plaintiffs sought to base liability "were all responsibly made at a planning rather than operational level and involved considerations more or less important to the practicability of the Government's fertilizer program." *Id.* at 42.

In *Miller v. United States,* 583 F.2d 857, 867 (6th Cir. 1978), we applied *Dalehite* to hold the discretionary function exception applicable to a case arising from the release of large quantities of water from Lake Superior to Lake Huron through the lock and dam system at Sault Ste. Marie. We pointed out that *Dalehite* itself relied on several lower federal court cases immunizing the government from liability in connection with the operation of dams and locks:

> In this regard, the Court cited with approval a number of District Court decisions involving claims of water damage. In *Lauterbach v. United States* [95 F. Supp. 479 (W.D. Wash. 1951)], the court rejected the plaintiffs' claim of damage due to the release of flood waters from a dam, based in part on the discretionary function exception as applied to the design and construction of the dam, and in part on a finding that there was in fact no negligence shown in its operation. In *Olson v. United States* [93 F. Supp. 150 (D.N.D. 1951)], the court granted a motion to dismiss plaintiff's claim that employees of the United States negligently opened the floodgates of a dam, destroying plaintiff's livestock; the court concluded that "*When* flood waters are to be released and *how much* water is to be released certainly calls for the exercise of judgment. . . . The Government's agents did not open the gate in the dam in a negligent manner. They merely abused their discretion as to *when* to open it." [93 F. Supp. at 152-53]

583 F.2d at 867 (footnotes omitted) (emphasis orginal). *See also Coates v. United States,* 181 F.2d 816 (8th Cir. 1950).

The viability of *Dalehite* was reaffirmed in *United States v. S.A. Empreso* (sic) *de Vincao* (sic) *Aerea Rio Grandense* (*Varig Airlines*), 467 U.S. 797 (1984). In that case, the Court held that the negligent failure of the Federal Aviation Administration to inspect certain aspects of aircraft design during the certification process was protected under the discretionary function exception. Most recently, a unanimous Supreme Court emphasized that the discretionary function exception does not preclude liability for any and all acts by a federal agency, but "applies only to conduct that involves the permissible exercise of policy judgment." *Berkovitz v. United States,* 108 S.Ct. 1954, 1960 (1988) (delegation to private sector of vaccine safety testing in violation of FDA regulations not covered by exception).

The District Court rejected the government's contention that all of the actions for which it was held negligent were, under the principles of *Dalehite, Varig Airlines,* and *Miller,* protected by the discretionary function exception. The actions which the District Court deemed negligent and unprotected by immunity were: 1) failure of the Corps to conduct periodic inspections of the Markland pool; 2) failure to replace the broken latch pin in a timely manner and allowing the pusher boat to become frozen in the auxiliary lock chamber; 3) failure to sufficiently train lock personnel; 4) failure to restrict the flow to the hydroelectric plant in order to have more flow through the gates, thereby increasing Markland's ice-passing capacity; 5) failure to coordinate ice-passing activities with Meldahl and to follow the same policy that Meldahl followed in maximizing the passage of ice; and 6) failure to compensate for the immobilization of the submergible tainter gates.

Applying the principles of these cases to this case, we conclude that the District Court correctly viewed the first three of the Corps' actions as involving operational, non-policy deci-

sions. The District Court erred, however, in its analysis of the Corps' decision not to restrict the flow to the hydroelectric plant and as a consequence not to follow the same policy of maximizing ice passage that the Corps followed at Meldahl. The Court also erred in its analysis of the Corps' decision not to compensate for the immobilization of the submergible gates.

B. The Hydroelectric Plant Issue

The District Court decided that the decision not to cut back flow to the hydroelectric plant was made entirely by the Markland lockmaster:

> Senior Corps personnel testified that, during the period here in question, the Corps was under pressure from the Governor of Indiana to maintain maximum output from the Markland generating plant. Power was needed because the United Mine Workers were on strike, and coal was at a premium. Thus, there are overtones of intergovernment relations, matters likely discretionary, which affect consideration of this point.
>
> However, Markland Lockmaster Sheldon testified that he had the authority to cut the amount of water diverted to the power plant down to 5,000 cfs. He did not testify that he had been instructed that the plant must be kept on line, nor did he testify that he was aware that pressure had been brought to bear upon his superiors to maintain the plant at full capacity.
>
> Had the Corps, through *e.g.*, Mr. Whitlock [one of Sheldon's superiors], either formally or informally ordered that the power plant be fed the maximum amount of water under all circumstances, it is likely that we would see that as a policy determination isolated from challenge by the discretionary function exception. However, because the point was not translated into an operation guideline for personnel at the dam, and because it is unquestioned that

> as the matter stood in January 1978, workers at the dam had the authority to cut back flow to the plant, we find that decisions, or omissions, regarding the extent to which water would be diverted to the hydroelectric plant fall outside the purview of the discretionary function exception.

Dist.Ct. opin. at 110-11.

The District Court's view that the power plant decision was nondiscretionary thus hinges on its finding that the Corps did not order the lockmaster to feed the maximum amount of water to the plant under all circumstances. But the record is clear that the decision was made at a higher level.

It is true that under normal circumstances, the lockmaster could vary the flow to the power plant; however, the record is clear that once the ice emergency and severe weather conditions began to create problems on the river in late January 1978, Corps policymakers became involved. General Heiberg, who was at the time the Division Engineer for the Ohio River Division, testified that the competing needs for power and navigability were weighed and that *he decided* that the need to generate power should prevail in that situation. *See* Tr. 4 -372-75, 4 - 431 (''[I]t was essentially my decision.''). District Engineer Whitlock also testified that the decision to continue maximum diversion to the power plant was made by balancing the competing needs for electricity and maintenance of navigation. Tr. 3 - 262-64, 3 - 337. Larry Dickson, who was directly under Whitlock and was the immediate supervisor of Lockmaster Sheldon, testified that while the plant was operating at near capacity, he discussed the plant with both Sheldon and Whitlock, and the decision was made to tell Sheldon to ''keep on doing what you're doing.'' Tr. 3 - 321-22. Sheldon testified that he was in communication with Whitlock and Dickson several times a day, and that *Whitlock* was making the decisions about passing ice. Tr. 763-64, 715. Thus, Sheldon was not exercising judgment in January 1978; he was merely carrying out the discretionary decisions of his superiors.

We emphasize that our inquiry into the factual question whether it was Sheldon or his superiors who were responsible for the power plant decisions is relevant only to determine whether a concededly discretionary decision was implemented. In undertaking this inquiry, we do not deviate from the principle that the character of the decision, and not the identity of the decisionmaker, determines whether the discretionary function exception applies. "It is the nature of the conduct, rather than the status of the actor, that governs." *Varig Airlines,* 467 U.S. at 813. The District Court correctly recognized that the character of the power plant decision by the Corps policymakers was discretionary, but it clearly erred in concluding that this decision was never effectuated. We are convinced that a definite mistake has been committed, and we reverse on this point. *United States v. United States Gypsum Co.,* 333 U.S. 364, 395 (1948).

C. The Markland-Meldahl Ice-Passing Issue

The District Court's ultimate conclusion was that "[f]ailure to pass ice at Markland proximately caused the ice gorge at Big Bone Island." Dist. Ct. opin. at 134. This decision was heavily influenced by the Court's view of action taken by personnel upstream at Meldahl. The District Court noted that "large amounts of ice were continually passed through Meldahl into the Markland pool," *id.* at 133, and concluded that "[a]ll this ice—ice coming through Meldahl, ice coming from tributaries, and ice forming in the Markland pool—had to go somewhere." *Id.* at 131. Thus, according to the District Court, the passage of ice at Meldahl combined with the failure to pass ice at Markland to cause the disaster.

This finding is rooted in two separate negligence findings. First, the Corps was found negligent for failing to coordinate ice passage between Meldahl and Markland. Second, the Corps was found negligent for failing to pass ice at Markland.

The record is clear that ice-passing efforts at Meldahl were not coordinated with efforts to manage the situation at Markland. The District Court found that

> [T]he lockmaster at Meldahl did not know what was going on at Markland, that the lockmaster at Markland did not know how ice was being passed at Meldahl, and that the Division personnel were unwilling to override the decision of District personnel in Huntington to maintain operations at Meldahl, although the Division personnel had better knowledge regarding the problems those operations were causing downstream.

Id. at 63.

While the District Court's conclusion that failure to coordinate activities between Meldahl and Markland contributed to the disaster may be correct, that failure is protected by the discretionary function exception. The District Court found that a "lack of oversight control" existed, but the Division personnel were exercising oversight control when they were apprised of the situation and decided not to override decisions made by lower-ranking personnel. That action by Division personnel may or may not have been made by considering all of the pros and cons of allowing Meldahl to keep passing ice, but "[e]ven the negligent failure of a discretionary government policymaker to consider all relevant aspects of a subject matter under consideration does not vitiate the discretionary character of the decision that is made." *Myslakowski v. United States,* 806 F.2d 94, 97 (6th Cir. 1986), *cert. denied,* 107 S.Ct. 1608 (1987). Division personnel decided that they would not instruct Meldahl to stop passing ice in order to "help out" Markland. Whether this was the correct decision is not for us to second-guess. The purpose of the exception is "to prevent the courts from intruding, through the vehicle of tort suits, upon the decisionmaking authority of the other branches of government." *Estate of Callas v. United States,* 682 F.2d 613, 620 (7th Cir. 1982).

The second way the District Court's decision was influenced by actions taken at Meldahl is seen in the finding that the failure to pass ice at Markland proximately caused the gorge. Essentially, the District Court reasoned as follows: Meldahl passed ice, and no jam formed above Meldahl. Markland did not pass ice, and a jam formed above Markland. Therefore, if Markland had emulated Meldahl and passed ice, no jam would have formed above Markland.

The problem with the District Court's analysis is that the situation at Markland and at Meldahl should not be treated as equivalent. As our discussion of the hydroelectric plant illustrates, the problems at Markland were unique. Meldahl personnel never had to balance the competing interests of navigation and generation of electricity, because the Meldahl facility did not have a power plant. Thus, the decision to pass ice and methods of passing ice at Meldahl are not comparable to the decisions made at Markland. Once the discretionary decision to continue supplying the hydroelectric plant with water was made at Markland, the courses of action open to Markland personnel were far more limited than the courses of action open to Meldahl personnel.

The low flows to the dam that resulted from the discretionary decision not to divert water from the hydroelectric plant left the Markland personnel with only three possible ways to pass ice: through the auxiliary lock chamber, through the main lock chamber, or by concentrating the flow to two gates and attempting to pass ice under those gates.

The District Court found that the auxiliary chamber could not be used because it was inoperable due to Corps negligence. We do not disturb this finding. The significance of this negligence is small, however. The record indicates that use of the auxiliary chamber to pass ice was "of limited utility" and "interfered with locking procedure." Testimony of Patrick Carigan, Tr. 45. Carigan also testified that "you shouldn't lock

vessels through [the main chamber] at the same time you're passing ice [through the auxiliary chamber] because it's too dangerous." *Id.* at 11.

The main chamber was not devoted to passing ice because the decision was made to continue locking boats through the chamber in an effort to maintain navigation. Lockmaster Sheldon was instructed to "lock boats and ice." Tr. 3-321. Carigan testified that the view of the Louisville District was that "everyone's interest would be better served by attempting to get as many of the boats out of that pool as possible. . . ." Tr. 13. He stated that the choice was "to lock rather than pass ice." *Id.* at 14. Although some ice was passed along with boats that were locked, the amount was small. The decision to maintain navigation at the expense of passing ice, however, is a decision the Corps is uniquely qualified to make, and is protected by the discretionary function exception. *See Estate of Callas,* 682 F.2d at 620.

The District Court also held that the Corps' failure to compensate for the immobilization of the submergible tainter gates by maintaining the structure in a condition that would permit underflow passage of ice at relatively low flows was negligent. Dist. Ct. opin. at 125. This holding is also in error. The record was clear that Corps personnel could not concentrate flow to two gates in an attempt to pass ice because of concern about "scour." The Corps' weighing of the need to pass ice against concern for the structural integrity of the dam is protected by the discretionary function exception. The District Court correctly held that the creation of the condition that precipitated the decision—the immobilization of the submergible gates—was protected by the exception. Dist. Ct. opin. at 104-06. It was error for the Court to then hold that the Corps' failure to compensate for the immobilization was negligent. Again, the Court slipped into the error of comparing Meldahl with Markland. At Meldahl, the lockmaster was able to "walk the gates"—concentrate flows for short periods at different gates—and thus com-

pensate somewhat for the immobilization of the submergible gates. At Markland, though, the flows were simply not high enough to pursue that tactic because much of the flow was diverted to the hydroelectric plant.

III. CONCLUSION

We have held that only the negligence concerning surveillance, training, and the auxiliary lock are unprotected by the discretionary function exception. It is clear from the District Court's findings that these negligent acts, standing alone, were not substantial factors in causing the disaster. The finding of causation is very close even when the Corps' conduct which we have found protected is included as a permissible cause. Once the actions that are protected by the discretionary function exception are removed from the causation equation, the District Court's finding can no longer stand.

This was a long and difficult case, and the District Court struggled valiantly with many complex issues. We hold, however, that the District Court erred in its discretionary function decision, and that error led to an erroneous finding of liability. Therefore, the judgment of the District Court is reversed.

UNITED STATES COURT OF APPEALS
FOR THE SIXTH CIRCUIT

Nos. 85-3990/4036
86-3216

IN RE: OHIO RIVER DISASTER LITIGATION.

COMPLAINT OF WALKER TOWING CORPORATION;
PETITION OF B-R RIVER SERVICES, INC.,
Plaintiffs-Appellees,
Plaintiffs-Appellants (86-3216),

B-R RIVER SERVICES, INC.,
Cross Appellant (85-4036),

v.

UNITED STATES OF AMERICA,
Defendant-Appellant (85-3990)
Cross Appellee.

Before: MERRITT and RYAN, Circuit Judges; and PECK, Senior Circuit Judge.

JUDGMENT

(Filed Dec. 5, 1988)

ON APPEAL from the United States District Court for the Southern District of Ohio.

THIS CAUSE came on to be heard on the records from the said district court and was argued by counsel.

ON CONSIDERATION WHEREOF, It is now here ordered and adjudged by this court that the judgment of the said district court in this case by (sic) and the same is hereby reversed.

Each party is to bear its own costs on appeal.

Entered By Order Of The Court

/s/ Leonard Green
Clerk

UNITED STATES COURT OF APPEALS
FOR THE SIXTH CIRCUIT

No. 85-3990/4036; 86-3218

IN RE: OHIO RIVER DISASTER LITIGATION

COMPLAINT OF WALKER TOWING CORP.;
PETITION OF B-R RIVER SERVICES,
Plaintiffs-Appellants/Appellees,

v.

UNITED STATES OF AMERICA,
Defendant-Appellant/Cross-Appellee,
Defendant-Appellee.

ORDER

(Filed Feb. 28, 1989)

BEFORE: MERRITT and RYAN, Circuit Judges; and PECK, Senior Circuit Judge

The Court having received a petition for rehearing en banc, and the petition having been circulated not only to the original panel members but also to all other active judges of this Court, and no judge of this Court having requested a vote on the suggestion for rehearing en banc, the petition for rehearing has been referred to the original hearing panel.

The panel has further reviewed the petition for rehearing and concludes that the issues raised in the petition were fully considered upon the original submission and decision of the case. Accordingly, the petition is denied.

Entered by Order of the Court

/s/ Leonard Green, Clerk

JUDGMENT IN A CIVIL CASE

United States District Court
Southern District Of Ohio
Western Division at Cincinnati

Docket Number
C-1-78-0075, C-1-79-0002, C-1-79-0208
C-1-80-0028, C-1-80-0591, C-1-80-0592
C-1-81-0414, C-1-84-0477, MDL 420

Honorable S. Arthur Spiegel, Judge

(Filed Sept. 24, 1985)

IN THE MATTER OF THE COMPLAINT OF WALKER TOWING CORPORATION FOR EXONERATION FROM OR LIMITATION OF LIABILITY

Consolidated with

IN THE MATTER OF THE PETITION OF
B-R RIVER SERVICES (N.D. Ky. C78-0217-L)

☐ **Jury Verdict.** This action came before the Court and a jury with the judicial officer named above presiding. The issues have been tried and the jury has rendered its verdict.

☒ **Decision by Court.** This action came to trial or hearing before the Court with the judge (magistrate) named above presiding. The issues have been tried or heard and a decision has been rendered.

IT IS ORDERED AND ADJUDGED

that judgment is entered in favor of petitioner Walker Towing Company, Inc. and against the United States in the amount of ONE MILLION FIVE HUNDRED THOUSAND DOLLARS ($1,500.00) together with interest from the date or dates of disbursement. Judgment is entered in favor of petitioner B-R River Services, Inc. and against the United States in the amount

of FIVE HUNDRED SIXTY—NINE THOUSAND THREE HUNDRED NINETEEN DOLLARS AND SIXTY CENTS ($569,319.60) together with interest from the date or dates of disbursement.

Clerk

Kenneth J. Murphy, Jr.

(By) Deputy Clerk

/s/ Elizabeth Schaeffer

Date 9/24/85

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF OHIO
WESTERN DIVISION
Civil Action No. C-1-79-208
MDL 420

IN THE MATTER OF THE COMPLAINT OF WALKER TOWING CORPORATION, A CORPORATION, FOR EXONERATION FROM OR LIMITATION OF LIABILITY

Consolidated with

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF KENTUCKY
AT LOUISVILLE

IN THE MATTER OF THE PETITION OF
B-R RIVER SERVICES. No. C78-0217-L(J) ETC

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UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF OHIO
WESTERN DIVISION
Civil Action No. C-1-79-208
MDL 420

IN THE MATTER OF THE COMPLAINT OF
WALKER TOWING CORPORATION, A CORPORATION,
FOR EXONERATION FROM OR LIMITATION OF
LIABILITY

Consolidated with

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF KENTUCKY
AT LOUISVILLE

IN THE MATTER OF THE PETITION OF
B-R RIVER SERVICES. No. C78-0217-L(J) ETC

OPINION AND ORDER

SPIEGEL, J.:

I.

These negligence cases arise under the Suits in Admiralty Act, 46 U.S.C. §§ 741-52. Petitioners Walker Towing Corporation and B-R River Services, Inc. seek damages from the United States for damages sustained by them and their shippers during severe ice conditions on the Ohio River in January, 1978. Trial was to the Court and included five weeks of testimony. Thousands of pages of deposition testimony from witnesses who did not testify at trial were considered, and more than thirty volumes of exhibits were admitted into evidence. Exhaustive proposed findings and conclusions have been submitted, as have separate memoranda of law on discrete issues. These cases thus stand fully submitted, and the following constitute the Court's findings of fact and conclusions of law, prepared in accordance with Rule 56(b), Fed. R. Civ. P.

II. SUMMARY OF HOLDING

For reasons which follow, we find and conclude that the United States was negligent in several aspects of its operation of facilities owned and operated by it, through the Army Corps of Engineers. The gist of the negligence findings are that the Government, under a duty to use due care in the operation of its locks and dams, breached that duty by, *inter alia,* failing to pass ice through Markland Locks and Dam as the ice came downstream during the middle weeks of January, 1978; failing to engage in routine surveillance of the reaches of the Ohio River upstream from Markland; failing to train its personnel in methods of handling and evaluating ice conditions; failing to ensure that the dam was in fact capable of dealing with reasonably forseeable ice conditions; and failing to intermittently restrict diversion of river flows to a hydroelectric generating facility located on the Markland site so that ice could be passed through the dam.

We also conclude that the acts or omissions detailed herein constitute deviations from the appropriate standard of care and were a proximate cause of the damages sustained by petitioners Walker Towing Company, Inc. and B-R River Services, Inc. However, we conclude that B-R River Services, Inc., was itself negligent, and attribute to that petitioner sixty percent of the responsibility for its recoverable losses.

Finally, we conclude that Walker Towing Company is entitled to recover for its losses in the amount of $1,500,000.00, and B-R River Services, Inc. is entitled to recover for its losses in the amount of $569,319.60, both together with prejudgment interest at the statutory rate from the dates on which petitioners settled with their claimants.

III. INTRODUCTION

The Ohio River runs 981 miles from Pittsburgh, Pennsylvania, to confluence with the Mississippi at Cairo, Illinois,

and has, for nearly two centuries, played a major role in the movement of cargo across the country. In furtherance of the river's role as a principle navigable waterway, the United States Army Corps of Engineers has, since it was given authority to do so in 1824, taken steps to render the river as navigable as technology and resources permitted, through an extensive canalization program.

In the early years of this century, the Corps installed more than 50 dams along the length of the main stem of the Ohio. These dams, called "low lift" or "wicket" dams ("low lift" because of the short height of the projects relative to modern locks and dams; "wicket" because they operate by means of a series of heavy timber wickets which are hinged to the riverbed), were rendered obsolete toward the middle of this century, and the Corps began replacing them with "high lift" or "non-navigable" locks and dams. ("High-lift" because each facility would raise or lower a vessel 35 feet, much more than the wicket dams: "non-navigable" because the dam proper is permanently affixed to the riverbed, so that vessels may never pass over the dam itself; when wicket dams are lowered, navigation proceeds over top of the wickets, bypassing the locks entirely.)

Since the late 1950s, the Corps has installed, and presently operates, 16 high lift locks and dam structures on the Ohio. Each such structure is massive by any standard. Markland Locks and Dam, around which this case focuses, consists of two lock chambers and 12 tainter (dam) gates. The auxiliary lock chamber, which adjoins the left descending (Kentucky) bank, is 600 feet long and 110 feet wide. The main chamber is 1200 feet by 110 feet. Each of the 12 steel tainter gates is 100 feet wide and 42 feet high. The entire structure is approximately 1500 feet wide, and the locks are capable of raising or lowering tows of up to 15 barges and a towboat, 35 feet.

In the winter of 1978, a number of different circumstances combined to set the stage for the disaster which is our concern

here. After a lengthy period of fluctuating weather forces which resulted in a substantial buildup of ice in the Markland pool,[1] of the Ohio, a violent storm hit on January 26; following the blizzard, a wall of ice and water moved downstream, sweeping a number of tow boats and barges into or through Markland Dam and causing losses mounting into the millions of dollars. Petitioners aver, *inter alia,*[2] that the Markland project was negligently operated in the days preceding the blizzard, thereby causing their losses.

These cases were filed in 1978, 1979, and 1980. They were, from May, 1980 until May, 1983, consolidated with numerous other cases related to the events of 1978, under the auspices of the Judicial Panel on Multidistrict Litigation, *see* 28 U.S.C. § 1407 (1976), as *MDL-420.* Following multidistrict proceedings before Senior Judge David S. Porter of this Court, the undersigned was assigned to act as trial judge in *In the Matter of Walker Towing Corporation and M/V AGNES MAE,* Civil Action No. C-1-79-208, and *United States v. Walker Towing Corporation,* Civil Action No. C-1-80-592. The third case here consolidated, *B-R River Services, Inc. v. United States,* Civil Action No. C-1-84-0477, was transferred for purposes of consolidation for trial from Hon. Edward Johnstone of the Western District of Kentucky in March, 1984, following remand to that court from the MDL proceedings.

After consolidation, Walker Towing and B-R River Services settled all claims with their shippers, and proceeded against the United States for indemnification. It is the indemnity claims which are presently under submission.

---

[1] The "Markland pool" is the stretch of river upstream from Markland to the next dam upriver.

[2] Petitioners also assert claims for negligent failure to warn navigators of potential hazards; negligence in the design and placement of Markland Dam, and others.

IV. FACTS

The factual discussion of this case has, as noted, been the subject of nearly five hundred pages of submissions by the parties. Trial exhibits fill some thirty volumes, and the parties have designated several thousand pages of deposition testimony, primarily from witnesses who did not testify at trial. In short, the volume of material is monumental.

A. Markland Locks and Dam — Overview

Planning for Markland Locks and Dam began in the early 1950s. Once the decisions where to put the structure and to include in it a hydroelectric plant to service parts of southern Indiana were made, the Corps commissioned model studies of the proposed structure to be performed at the Corps' Waterways Experiment Station (WES) in Vicksburg, Mississippi (Exhibit 16). The model studies, begun in 1953, revealed that the facility would likely be subject to certain recurring problems which would require care in operating the facility. One of the more serious concerns addressed in Corps memoranda was the potential for problems in passing accumulations of ice and drift which would float down on to the dam. The potential for problems stemmed from a number of circumstances. One of the major concerns was that the site chosen for the structure was immediately downstream from a moderate right-hand (descending) bend in the river, the effect of which was to channel floating debris into the lock approach area.

Recognizing the problem, the Corps considered various solutions. One proposed solution was the inclusion of an "ice and drift chute," a cut through the lock wall to pass ice and debris. That option was strongly recommended by certain Corps personnel during the design phase (Exhibits 156, 157, 158). However, the chute was rejected, primarily because it created potential hazards for navigations (Exhibit 1368B at 20 ¶ *c*). Instead, the Corps decided to implement a type of dam tainter gate which could be submerged below the surface of the water

to permit overflow of ice and drift as it came downstream, as well as being operable when raised up off the river bed. The reasoning behind the submergibility feature was that while relatively high volumes of water are essential to create suction sufficient to pull floating material under a gate raised off the river bed, much less force — and hence less water volume — is necessary to pull floating objects over gates lowered beneath water level.

Submergible tainter gates were a relatively new device at the time of the Markland feasibility studies. Such gates had been used for some time in certain Western rivers, but the Markland project was the first on the Ohio which would incorporate them. When submergible gates were included in the WES model, they were found to work satisfactorily (Exhibit 136D at 11-12). The gates were found to vibrate slightly when submerged (*id.*), but the vibration was within acceptable limits. In fact, the Corps was apparently well-satisfied with the concept of submergible tainter gates, for such gates were incorporated into several high-lift dams on the Ohio River. And, at least at Markland, the submergible gates represented the only design feature specifically geared to passage of ice and drift; a 1957 design memorandum (Exhibit 136) notes that "[f]ive submergible type gates at Markland is [sic] regarded as a minimum to assure [sic] the desired reliability of passing ice and the flexibility in passing debris." *See also* Exhibits 159, 160.

Construction on Markland commenced in the late 1950's, and the facility was largely operational by early 1963; a number of other Ohio River high-lift structures also became operational at about the same time. By the middle of 1964, operation of the submergible gates at structures other than Markland proved problematic. At McAlpine Locks and Dam, the next facility downriver from Markland and located in the Louisville Harbor, "violent vibration of [a] gate broke out" when the gate was operated in its submerged position (Exhibit 230A at ¶ 4).

It appears that while certain corrective measures were attempted at some of the other facilities to overcome the submergible gate vibration tendencies, no steps were taken at Markland save to severely restrict use of the submergible gates. In February, 1966, however, a team of Corps employees visited the Markland site "mainly to observe vibration tendencies of the submergible gates and ice conditions." Each of the five submergible gates at the dam were operated in the submerged mode:

> Gate 1 was lowered first and left on its pedestals. No vibration was observed. Gates 6 and 7 were next lowered to their pedestals and only slight vibration could be detected, mainly by observing occasional small vibrations of the hoist cables after being lowered about 2 feet. These 3 gates were left lowered on their pedestals without noticeable vibration in this position.
>
> Lastly, gate 8 was lowered to its pedestal with only slight vibration on the way down, about the same as gates 6 and 7. A few minutes after resting on its pedestals, the gate began to vibrate with sufficient serverity to be felt in standing on the walkway near the hoist and to rattle the door of the hoist housing. The gate was immediately raised; when up about a foot the vibration stopped; it was raised another foot and left in that position without noticeable vibration.

Exhibit 232 at ¶¶ 5-6. Because there is nothing in the record which contradicts that exhibit, we find as a fact that there was no significant problem with vibration of submergible tainter gates at Markland Dam. *See also* Exhibit 303 (Vibration of gate 7 at Markland found to be "of no consequence").

Despite the lack of a significant vibration problem at Markland, dam personnel were not permitted to utilize the submergible gates as even a backup, much less a primary, means of passing ice and drift. Testimony from a number of Corps personnel, including Norbert Whitlock, was to the effect that

operation of gates in the submerged mode was an unproductive method of attempting to pass ice which had stopped or formed as a sheet upstream from the dam, as it tended to break off just up from the gates and move no further. That testimony is to some extent supported by the observations recorded in Exhibit 232, where stationary ice was noted to bridge over when attempts were made to pass it over submerged gates. However, that inadequacy, whether perceived or real, was not the reason that the gates were not used in a submerged mode. Rather, we conclude that the Corps responded to its concerns about significant vibration at only a handful of submergible gates — including none at Markland — by discontinuing the use of all submergible gates at all structures on the Ohio River. It is essentially undisputed that this action was taken without preliminary recourse to then-available methods for testing and analyzing the cause of the stress (testimony of Dr. Martin), although Corps personnel did attempt to determine the cause. *See* Exhibits 161, 161A, 161B.

As noted, the five submergible tainter gates could also be utilized as raisable gates, meaning that all twelve gates could be raised. A tainter gate can be visualized as a pie-shaped wedge which pivots at its point, the gate face being a steel slab connected to the wide end of each pie-shaped arm. A non-submergible gate can only be pivoted upward, thus permitting water to flow under the gate, a submergible gate can pivot either up or down. In the submerged mode, the lower edge of the gate, and a portion of its curved face, are lowered below the sill which marks the river bottom; the pulleys and hoist cables which support the gate are thus under constant tension as the gate is always being supported. A non-submergible gate, on the other hand, rests on a sill which wholly supports the gate, so that there is less stress involved.

The sill upon which a gate rests (or with which a submergible gate interfaces) is some 35 feet below the normal level of the Markland pool. Thus, if a gate is raised up one or two feet off

its sill, it is improbable that flotsam would be pulled down far enough to pass under a slightly raised gate. While estimates varied, we find, based upon testimony from Carroll Sheldon, past Lockmaster at Markland, and others, that gates must be raised at least 10-12 feet off their sills before enough suction will be generated to draw floating ice or drift below the surface and thus under raised gates. In addition, testimony established that at least two adjacent gates must be so raised before movement of flotsam occurs.

Thus, the obvious problem with attempting to pass ice through manipulation of non-submergible tainter gates is that it can only be done when there is sufficient flow in the river — enough water coming downstream — that two gates can be opened enough to start drawing ice under without causing the level of the pool to fall below navigable levels, an occurrence which creates crisis in its own right.

In addition, because of long-standing concern regarding the integrity of the riverbed immediately downstream from Markland Dam, and the possibility of unacceptable scour (erosion), the Corps had determined that concentration of flows on two adjacent gates was generally unacceptable as an operating mode unless river flows were so high that all gates could be opened equally, or unless the downstream pool was deep enough that such fears could be put to rest.

Testimony established that while steps have been taken in recent years to buttress the riverbed downstream from Markland to withstand greater forces than were initially believed advisable, no substantial steps were taken in that area prior to the events of 1978. *See also* Exhibit 161.

Yet another difficulty attendant to the use of raised gates for underflow passage of ice and drift was presented by the diversion of water to the hydroelectric plant on Markland's Indiana shore. The plant was routinely operated at or near its full capacity of 35,000 cubic feet per second (cfs) of flow, according

to the testimony of Lockmaster Sheldon. He testified that on the average, he assumes that one foot of gate opening on one gate passes 5,000 cfs of flow; the 35,000 cfs used by the hydroelectric plant, then, represented at least seven feet of gate opening — and likely more — which was generally considered unavailable to Markland personnel for underflow passage.

In short, the option of passing ice under raised tainter gates at low flows was, as a practical matter, largely foreclosed by Corps practice except under narrowly defined circumstances.

We leave the subject of tainter gates to examine the only other potential ice-passing mechanism designed to be available to Markland personnel. As noted, the structure includes two locks. The main lock lies on the left descending (Kentucky) side of the dam, riverward from the auxiliary chamber. As noted, the main chamber is 110 feet wide and 1200 feet long, while the auxiliary chamber, which is the shoremost portion of the facility, is 110 feet wide and 600 feet long. The principal method of operating the locks is by way of mitre gates which swing out from the walls of the lock chambers to close the chamber for filling or emptying, and swing back into the lock walls to permit vessel entry or departure. In addition to the mitre gates, each lock has, at its upstream end and above the upper mitre gates, what are called emergency leaves. Each emergency leaf is a straight, one-piece affair which lifts by way of hoist cables out of a recess built into the riverbed. By pinning the upstream mitre gates back into the lock wall and raising the emergency leaf until it is just below the level of the upstream pool, a lock chamber can be used to "skim" ice or drift. That is, as water flows over the emergency leaf, it carries with it ice or drift, and carries it on through the lock chamber and downstream.

Markland's main lock chamber emergency leaf, due to a design problem, had been constructed with only four inches of freeboard (*i.e.*, it rose only four inches out of the water at normal upper pool stage); although this design flaw did not make

use of the main chamber for skimming purposes impossible, it caused the Corps to discourage use of that leaf in general because several practical considerations militated against its use. In addition, use of the emergency leaf in the main chamber rendered navigation through the locks impossible, as it constitutes a solid wall blocking entry to the lock. Thus, the emergency leaf on the main chamber was never considered a significant part of Markland's ice-passing capacity.

In short, Markland operated from its inception under certain significant operational constraints. The Corps knew when the structure was designed that its location presented special problems with regard to ice and drift problems, in addition to the obvious problems in that regard posed by any huge structure which completely blocks a large river. In response to those concerns, the Corps engineered into the facility submergible tainter gates, expressly designed for passage of ice and drift at low flows. The Corps then determined, based upon isolated incidents, that those gates would not be used as submergible gates. The structure was, at best, left with only one means of dealing with ice when flows were below the level at which gates could be raised up and ice pulled under — use of the auxiliary chamber and its emergency leaf to skim ice as it came downstream.

B. Historical Background

Fortunately, the years following the completion of Markland presented little problem with ice accumulation at the dam. The parties stipulated that in the years from 1963-76 (with information unavailable for 1965, '66, and '67), ice accumulated in only three winters. In 1963, Markland reported extensive ice cover during the last week of January. In 1969, extensive ice occurred on January 5 and January 14-18. In 1970, extensive ice was reported intermittently during the last two weeks of January (Stipulations of Fact at ¶ 6, Table 1). No evidence was adduced as to how, if at all, Markland personnel dealt with ice in 1969 or

1970; as noted above, Exhibit 232 notes only that in 1963, a party of Corps personnel sought to test the ability of the submergible tainter gates to induce passage of bridged, stationary ice above the dam; no other record of the ice from 1963 was introduced. In short, it appears that Markland operational personnel had little experience with major ice problems in the period of 1963-77.

Several other historical points relating directly to Markland bear mention before we discuss the winters of 1977 and 1978. Petitioners' Exhibit 161 is a February, 1975 letter from John R. Bleidt, Chief of the Operations Division of the Ohio River Division of the Corps of Engineers, to a power company official concerned about accumulations of "drift and miscellaneous trash" above the Markland hydroelectric generating plant. The gist of the letter is that the problem was insoluble. After noting that such accumulations "will probably continue to be a problem which will be costly to both you and the Corps," Bleidt noted that

> [t]he dam was constructed with five submergible tainter gates (1, 6, 7, 8 and 12) which were designed for passing drift, etc. However, due to vibration problems at certain stages, the passing of a [sic] drift over the tops of these gates had to be discontinued. At this time the five submergible tainter gates had to be discontinued. At this time the five submergible tainter gates are operated as non-submergible tainter gates. As non-submergible tainter gates, water flows under the gate rather than over the gate. It has been our experience that a gate has to be raised approximately eighteen feet before drift above the dam is sucked under the gate and flows on downstream.
>
> I would also like to point out that the area just downstream of the dam is protected by derrick stone. High concentrated velocities in these areas tend to wash the stone downstream and thereby causes erosion of the riverbed in

> the area just below the stilling basin. Because of this problem, regulations governing the operation of the tainter gates were established. It is our policy that all gates, except gate No. 1 be opened within one to two feet of each other. This means that for gates 11 and 12 to have an 18 foot opening on each one, all other gates with the exception of gate 1 will also have an 18 foot opening.

Id. Thus, the Corps knew throughout the operational life of Markland that the structure was handicapped in its ability to pass ice and drift; the Corps prohibited the use of the submergible gates in a submerged mode, and the concern about conditions below the dam prevented the efficient use of the raised gates for ice or drift passage under any but the highest flows.

To summarize, then, the situation at Markland regarding ice and drift passage in the middle years of the 1970s was as follows:

— The Corps was aware that the location of the structure posed particular problems with regard to accumulation and passage of ice and drift.

— The submergible tainter gates, the principle ice-passing mechanism built into the dam, were inoperative as a matter of Corps practice.

— Concern regarding the potential for downstream scour caused the Corps to institute the practice of not passing ice or drift under raised tainter gates when river volume was below a certain level.

— The auxiliary chamber emergency leaf could not be used for skimming ice because the mitre gate latch pin was broken (this was not mentioned above, but is discussed *infra*).

— The main lock chamber emergency leaf could not be used for passing ice because it was designed with insufficient freeboard to permit such operation.

— The hydroelectric plant was routinely permitted to use the first 35,000 cfs of river flow, thus greatly reducing (especially in periods of low-to-moderate flows) the amount of water available to the structure proper for passage of ice and drift, a condition which led to routine accumulations of large amounts of drift above the structure and the hydro plant.

C. Ice Conditions

We now turn to examination of several matters pertaining to ice. These include ice conditions on the Ohio in the twentieth century, an ice gorge at Markland in 1963; ice conditions during the Winter of 1977; and Corps documents dealing with ice operations.

1. Twentieth Century Ice.

As part of its contribution to the Ice Committee Investigation of the events of 1978, the National Weather Service generated a table reflecting ice conditions on the Ohio River during the period from 1874 through 1978 (Exhibit 179 at Exhibit 1). The NWS found that

> Ice has appeared in the Ohio River at Cincinnati in 62 of the past 90 winters since 1874, 28 winters (31.1%) having been without ice. While the formation of ice is directly related to the temperature of the water which must be at or near freezing, the official minimum atmospheric temperatures at Cincinnati have averaged as follows: with the occurrence [sic] of *light ice* 13°, *heavy ice* 9°, *frozen* 3°.
>
> Light floating ice has usually been followed in about one day by heavy floating ice; and the river has usually frozen over after about three days of heavy ice. Actually, however, considerable quantities of light ice have appeared 66 times and heavy ice followed it only 49 times; while heavy ice appeared 15 times without light ice preceding it. The river has frozen over in only 13 winters in the [period 1874 - 1964], always following heavy or gorged ice.

Id. (emphasis in original). Of the 1302 days in which ice occurred on the river during the 90 years in question, 614 (47%) occurred during January; of the 497 days of light ice, 48% were in January; of the 492 days of heavy ice, 45% occurred in January; of the 116 days on which the river was frozen over, 49% were in January; and of the 197 days on which the river gorged, 51% were in January. 18% of the "ice days" occurred in December, and 34% in February. *Id.* These figures, of course, pertain only to the years prior to completion of the high-lift dams on the Ohio. As such, their value is to some extent anecdotal; as discussed at the outset, high-lift dams create deeper pools of water between structures, and, as the parties have stipulated, "[t]here is reason to believe that deeper water retards the development of ice and formation of jams." Stipulation, doc. 219, at ¶ 2. The parties have further stipulated to a Corps-generated chart which shows ice conditions at Markland for most of the period from 1963-1978:

TABLE I

Year	Some Ice	Extensive (80-100%) Ice Cover	Extensive Stationary Ice	Extensive Running Ice
1963	Jan 25	Jan 26-31	Jan 26, 28-31	Jan 27
1964	Jan 2	None	None	None
1965-1967	RECORDS NOT AVAILABLE AT THIS TIME			
1968	Jan 16-17	None	None	None
1969	Jan 12	Jan 5, 14-18	Jan 5, 14-18	None
1970	Jan 11-15, 20-21, 25-26	Jan 22-24, 27-28	Jan 22-24, 28	Jan 27
1971	Jan 17	None	None	None

1972	Jan 16	None	None	None
1973	None	None	None	None
1974	None	None	None	None
1975	None	None	None	None
1976	None	None	None	None

Id. at ¶ 6, Table I. As Table I demonstrates, there was at least some ice on the river in seven of the eleven Januaries for which information was available, while extensive ice occurred in three of those eleven years. Each time heavy ice appeared, it was stationary for the majority of its tenure. The Table suggests that the last half of January is a particularly likely time for heavy ice to build up on the river.

> Ice in the river can cause substantial damage. In 1918, for example, the Ohio River was closed by ice from Pittsburgh to the Mississippi River and at Cincinnati, ice caused navigation to suspend operations for more than two months. When the ice gorged and broke, all along the river, there was substantial damage to towns, power plants, boats and the Cincinnati Harbor.

Id. at ¶ 5. The winter of 1918 was, as review of the Ice Report exhibit demonstrates, the worst since the canalization program began, in terms of the duration of the period for which navigation was suspended and the damages which resulted from the thaw. However, ice on the river was, as all witnesses agreed, a foreseeable occurrence. Review of the exhibits shows that while ice in the months of December, January, and February could be reasonably expected, it is most likely to occur in January, and we so find. We note that Mr. John Mitchell, former Chief of the Corps's Reservoir Control Center in Cincinnati, testified that he authored statements for the Ice Committee Report to the effect that ice appears on the Ohio on an average of two of every three years; that heavy running ice appears on the average of every other year; and that the river has frozen over (in Cincinnati) on the average of one in seven years (Tr. I at 241).

Mr. Patrick Carigan, a civil engineer with the Corps as well as an expert on the river (and Chairman of the 1978 Ice Committee), also testified that the following were reasonably foreseeable (although not necessarily, in his view, predictable) *vis a vis* the Ohio-River:

> — Formation of ice on the river during periods of cold weather.
>
> — Formation of ice during periods of low flows and cold weather.
>
> — Accumulation of significant amounts of ice.
>
> — Movement of ice downstream towards Markland Dam.
>
> — A continuous supply of water flowing downstream in the main stem.
>
> — Collection of whatever ice and drift came downstream at the dam.
>
> — The possibility of extensive running ice in the river, based upon the historical observation of such occurrence twice in 14 years prior to 1978.
>
> — The need to lock boats through during periods of ice and low flows.

(Carigan Test. July 31, 1984.) Following that litany, Mr. Carigan testified that, in his opinion, a reasonably prudent engineer charged with operation of Markland Locks and Dam would take reasonable steps to minimize operational limitations imposed on Markland by its design and by the operational constraints imposed upon it (*id.*). He also testified that reasonable prudence would demand an operations plan which took into account the weather, hydraulic and operational variables reasonably foreseeable at Markland.

We agree with Mr. Carigan and others who testified, and later in this opinion conclude as a matter of law, that the Corps had a

duty to use due care in formulating ice operations plans for dealing with contingencies such as weather and operational limitations at Markland. We now turn to examination of those operational plans which were potentially applicable to operation of Markland Dam.

2. Ice Plans and Their Use at Markland.

As discussed earlier, the Corps has, from the earliest stages of the Markland project, recognized the need for ice and drift passage at the structure. A memorandum from the Chief of the Ohio River Division Engineering Division in Cincinnati to the Louisville District Engineer dated October 13, 1964 and pertaining to necessary revisions of the Markland operations manual, mandated that

> [a] new chapter should be added, or a paragraph added, for each section on unusual conditions and the corrective measures to be taken. Such as:
>
> * * *
>
> i. How to pass ice and debris with the vertical lift gate.
>
> j. The operation of the dam gates for passing ice, also low flows and the reasons therefore.

PX 165 at 5. A previous memorandum from the Deputy Division Engineer, dated October 8, 1963 and pertaining to the Markland manual, provides that

> [t]he Operations Manual should contain instructions for the operation and use of the emergency gates for skimming or flushing the lock, for prevention of jamming of the upper mitre gate by drift or ice, and for using the lock as spillway.

Id., 2d Memorandum at 2.

It appears that Corps personnel responsible for revision of the Markland operating manual did comply, no later than 1972,

with the requirement of instruction regarding use of the emergency gates for passage of ice and drift (*id.* at § XVII-2), providing that

> [s]ubmergible gate No. 7 has a tendency to vibrate when submerged under some conditions. This gate should not be used in the submerged position until this problem is rectified. Any submergible gate which shows a similar tendency should not be used in the submerged position.

However, review of the manual does not disclose any provisions dealing with use of either the submergible or the non-submergible tainter gates for passage of ice or drift. This seeming omission contrasts with the operating manual for Meldahl Locks and Dam, which provides that the "submergible gates are designed to allow lowering the gate to a depth which permits flow at normal pool over the upper edge. This feature contemplates skimming ice and debris from the surface of the upper pool" (PX 165A at § 6-1). The Meldahl manual further provides as follows:

> d. *Skimming operation.* The removal of floating debris, and ice from the surface of the upper pool is accomplished by operation of submergible gates Nos. 1, 6, 7, 8 & 12. The operation of one or more gates and amount of submergence of each will be determined on the basis of existing conditions including extent of accumulation and amount of flow. Normally, non-submergible gates will be closed on either side of the gate used for skimming operations to facilities [sic: facilitate] movement of debris or ice to the submerged gate . . . . Skimming should be scheduled to prevent any buildup of debris and ice.

We note, too, that the Meldahl manual provides detailed instructions comprising three pages of text regarding proper procedures for using the lock emergency gates for passage of ice and drift (*id.* at § 4-05), while the Markland manual provides only one brief paragraph addressing the point.

Throughout the period after which Markland came on line, various ice regulations or instructions were provided to its personnel, albeit not expressly written into the manual. The first of these is a document entitled "Division Circular No. 16-58" (Exhibit 113B). Dated October 14, 1958, the document purports to be effective through October 14, 1962; however, a handwritten notation on it reflects that it was a "file copy rec. 1-14-77" — a time when Markland was experiencing ice problems.

The parties disagree as to the relevance of Exhibit 113B to operations at Markland. Petitioners assert that the document was the then-controlling ice regulation, while the Government urges that it is of only anecdotal value, and that the controlling ice plan was one drafted in mid-January, 1978, dated January 23, 1978, and transmitted to the dams no earlier than the 23rd (Exhibit 113A). Because Exhibit 113A was not in the possession of Markland personnel until after the conditions complained of had been permitted to develop, and because the earlier ice regulations were in fact on-site at the dam, we find that Exhibit 113B was, insofar as it did not expressly apply to low-lift dams, applicable to operations at high-lift dams. We note, in this regard, Mr. Carigan's view that prudence dictated that *some* plan be generated to guide dam personnel in operating the structure in ice conditions; we also note that the copy of 113B retrieved from Markland bears a 1977 file date. We thus find that the document was, at the time these conditions arose, applicable to operations at Markland.

The document, "issued to govern the lock and dam operation, patrols, collection and reporting of data, in all districts during critical ice periods," pertains in part to operation of old wicket-type dams. However, petitioners persuasively argue that at least two of its provisions are relevant to operations at high-lift dams as well. The first provides that

> [i]n order to facilitate the movement of navigation while the dam is in operation, the ice forming in the approaches

and around the gates shall be kept broken and the gates maintained free of ice as far as practicable by use of the maneuverboat and by lockage of ice from the upper to the lower pool . . . .

When sub-freezing temperatures and the formation of ice make it hazardous to navigate the pool and it is probable that conditions will become worse, navigators in the area should be warned to seek safety immediately in an ice harbor. All practical warning, advice, and assistance shall be given to navigation interests.

* * *

Ice patrols should be established whose duties are as follows:

(1) To collect pertinent information concerning ice gorges.

(2) To collect data on damages to structures and plant owned by both the U.S. Government and private interests.

(3) To relay pertinent information to the District Engineer.

(4) To take photographs.

(5) To collect other information desired by the District Engineer.

Id. at ¶¶ 9 i-j, m.

The next bit of evidence pertinent to ice-control problems is Petitioner's Exhibit 211, an "order" dated February 11, 1964, from the Deputy Division Engineer entitled "Ice Conditions on Non-Navigable Type Dams." The order first notes that "[t]he ice conditions which have occurred in recent years give cause to alert those responsible for operations of the non-navigable type dams." It then notes, excerpting a previous memorandum, that

'[i]t is apparent . . . that operations to preclude ice hazards should be clarified. Non-moving sheet ice gives no problem. It is only when ice starts to move under natural conditions (and efforts to move otherwise are of little effect) that hazard is created. *The only safe operation then is to pass all ice through the dam as it arrives, and to have essential provisions for such passage.* Such movements generally follow the thalweg of the stream. Movements during low flow can be passed over one gate (7 to 8,000 cfs at 7 feet depth). Increased flows with ice would be passed over other adjacent gates. Any tendency for skimming of ice by underflow gates should be discouraged. The opening required for passage of ice by underflow will vary with the ice formation and tailwater-head relations. An assured passage may be 50 percent opening, which in this project would pass 26-30,000 cfs per gate. Failure to pass one-inch thickness of ice can form a serious gorge, and such has happened on one occsion through operational failure to provide passage of it. Fluctuations in pools are not contemplated, but minor ones may result under some conditions of passing ice on arrival.'

Overflow submergible gates have been provided to pass ice and debris until tailwater builds up sufficiently to permit safe under-gate passage. Concentration of heavy flows with low-tailwater for under-passage is not contemplated. In fact, the apron design does not provide for such condition . . . .

Exhibit 211 at 1 (emphasis supplied).

As this exhibit demonstrates, the Corps was well aware of the potential for severe problems resulting from accumulation of ice. This memorandum followed by one year potentially serious ice conditions at Markland, reported in Exhibit 508. In February, 1963, ice formed in the Markland pool. Buildup was enough so that ice problems extended as far as Cincinnati,

where, according to the exhibit, a gorge had formed. Markland was still under construction at the time, and a coffer (construction) dam extended nearly halfway across the river. The draft memorandum reflects that, from February 4 through February 6, gate manipulations were used to start ice moving.

> On 4 February Gates 7, 8 and 12 were submerged and ice immediately above dam as far as the upper end of guard wall slowly moved and that immediately above lowered gates went on over. The ice behind the coffer did not move. This ice was mostly clear sheet ice.
>
> On 5 February Gates 6, 7, 8 and 12 were carried submerged throughout the day. Gates 9, 10 and 11 discharge was increased during the day to 20', 18' and 16' respectively. Very little additional ice passed during this time. However, the gorge which was at Cincinnati moved to the area from upper end of Warsaw to Big Bone Island.
>
> On 6 February decrease in flow of water evidently from ice jam made it necessary to close Gates 9, 10 and 11 to 12', 14' and 14' respectively, this was between 5:00 am and 7:00 am. At 9:45 am Gates 11 and 9 were closed 5' more to effect a raise in pool to break ice jam above Warsaw, later Gate 11 was completely closed . . . to bring pool up to 12.0 an upper gage. (6, 7, 8 and 12) completely submerged.)
>
> At 12:45 pm river level reached 12.2 on upper gage and began opening gates to pass the ice gorge. Gate No. 9 was opened to top of water. Ice began moving at Mile 518 at 1:00 pm. First ice passed dam at 1:20 pm, this was mostly sheet ice, some passed over the submerged gates and other through the raised gates.

Id. at 1-2. This exhibit, then, demonstrates that through careful adjustment of submergible and underflow gate openings and pool levels, Markland was able to handle ice conditions, an ice gorge and attendant large amounts of ice without significant incident. The author concluded that

> The submergible gates in dam are adequate to handle scattered flow of drift or scattered single layered ice, provided that other gates do not have too large an opening. If running a large amount of water, the currents carry to these gates and drift or heavy ice is sucked under the raised gates. Under heavy gorged ice conditions the submergible gates will not handle this type ice.

Id. at 3.

As we read this document, it suggests that the submergible tainter gates performed as they were supposed to. When the river flow fell too low for passage of ice beneath raised gates, the submergible gates were used, and were able to pass floating ice upstream of the dam. The submergible gates could not be used to pass large amounts of ice at high flows, or to pass solid ice; the reason for this is reflected in Defendant's Exhibit 527. This document was prepared by David Beatty, Chief of the Hydraulics and Hydrology Branch, Engineering Division of the Louisville District of the Corps. It demonstrates that a gate raised off the river bed so that water passes under it will pass a greater volume of water per foot of gate opening than a gate submerged below the surface. Of course, water at the bottom of the river is under greater hydraulic force than that on the surface, and so more will pass. Thus, the submergible gates were shown to be able to pass ice and drift to some extent at low flows.

Consideration of the report of February, 1963 (Exhibit 508) with the 1964 ice operations memorandum (Exhibit 211) suggests that the two mesh fairly well. As provided in Exhibit 211, ice movement "during low flow [was] passed over" the submergible gates. Ice was not passed by underflow gates until the flows returned to a level at which such passage was practicable. Once the ice was moving, it was passed "as it arrives," and the dam "[had] essential provisions for such passage." The only significant variance was that the project was operated so as

to raise the level of the upper pool a few inches to try to break loose the gorged ice upstream, a practice called "bouncing the pool." In sum, the 1963 ice operation, while not flawless, worked well enough that the ultimate conclusion regarding the experience was that "[t]here were no significant operating difficulties" (Exhibit 508 at 1).

Despite this fact, it does not appear that the submergible tainter gates would again play a part in ice or drift passage at Markland. At a 1964 conference, submergible gates were debated:

> there was some discussion over the need for submergible gates and their effectiveness in passing ice and prevention of ice jams at the dams. OCE [Office of the Chief of Engineers] representatives pointed out that attempts to pass ice with submergible gates at Greenup and Markland had not been very successful because currents strong enough to move packed broken ice could not be produced with flow over the submergible gates. ORD [Ohio River Division] representatives stated that ice could be passed with lowered submergible gates as it reached a dam if proper operation was followed at the beginning of an ice run. Pittsburgh District representatives disagreed with this view and stated that at Emsworth Dam, where all of the gates can be lowered 3 feet, ice jams and packs would form above the dam regardless of how the gates were operated. No agreement was reached . . . .

Exhibit 507 at 5.

Two months after this conference, in September, 1964, OCE personnel determined that "satisfactory operation of submergible gates cannot be assured, and they should not be provided at Ohio River Dams" (Defendant's Exhibit 554). The exhibit is captioned "Elimination of Submergible Tainter Gates at Belleville Project," and concludes that such gates should not be included in a then-planned (but not yet constructed) Ohio River

dam. The Government would have us find that "[p]ursuant to [Exhibit 554], submergible gates were not operated at the early high lift dams, and were not provided at Belleville, Cannelton or any subsequent high lift dam" (Proposed Findings, etc. of March 7, 1985 at 28). We disagree with the first portion of that proposed finding, for the memorandum does not purport to address operation of submergible tainter gates at existing high lift dams. Rather, we find that the memorandum applies only to projects then on the drawing board. The point is, however, likely mooted by the fact that reliable Corps records, as well as credible testimony, demonstrate that, during the summer of 1977, the submergible tainter gates were rendered physically nonsubmergible by installation of concrete and steel stops designed to prevent submergence.

As noted above, there occurred, during the winter of 1976-77, severe ice conditions at Markland. The summer and fall of 1976 were extremely dry, resulting in reduced river flows. We excerpt the Ice Committee Report:

> [R]ecord-breaking low temperatures and low precipitation during November and December brought steamflows to record lows by the end of December and ice had formed along the major northern and eastern Ohio River tributaries . . . . January 1977 saw a worsening of conditions as extreme cold resulted in massive ice formation on most of the basin's streams.
>
> Needless to say, navigation was severely impacted by ice everywhere on the Ohio. However, there were two distinctly different kinds of ice problem. On all of the newer navigation pools upstream from Uniontown Dam, bank-to-bank sheet ice kept tow movements at a slow pace. Although some companies ceased operations, many continued to operate, slowly but steadily, breaking their way through clear, sheet ice. This action, in and of itself, resulted in some minor layering in each of the new pools.

> However, absent was the massive layering that subsequently produces the kind of jagged, jumbled concentration of ice that jams at the first hint of a constriction.
>
> Unusually low steamflow had resulted in extremely low velocities-velocities too low to force broken ice up over or down under the stationary ice. Some ice would be displaced as tows broke their way through and the river would refeeze (sic) behind the tows, but the major volume of ice remained in place, frozen to banks.

Exhibit 192 at Appendix 1, p. 4. Later in January, an ice gorge formed at Carrsville, Kentucky, downstream from Louisville, due to rainfall and "uncontrolled runoff over southern portions of the basin" leading to increased steamflows and accumulation of ice.

Review of the records generated during and after the events of 1977 demonstrate that the ice which formed at Markland and other high-lift dams on the upper Ohio River was bank-to-bank sheet ice which formed locally. Because of the low flows and velocities extant, the ice did not move for several weeks. As noted above, Corps ice strategy provides that "[n]on-moving sheet ice gives no problem" (*e.g.*, Exhibit 211 at 1); thus, the action taken at Markland and other high-lift dams on the Ohio in simply leaving the ice to its own devices and passing it as it began to break up was appropriate.

Before turning to the events of the winter of 1977-78, we summarize the foregoing. Markland was designed to have the following mechanisms for handling ice problems: submergible tainter gates; raisable tainter gates; lock chamber emergency leaves. The submergible gates were placed in the dam especially for use during low flows, *i.e.*, when the nonsubmergible gates could not be raised far enough off their pedestals to pass ice without risking loss of pool. The emergency leaves were useful for passing moving ice in the lock approach areas, but were too far toward the Kentucky shore to pass all ice moving

downstream. In addition, the main chamber emergency gate, by virtue of its inadequate freeboard, was effectively unusable for ice passage. Finally, in 1976, a large latch pin essential for use of the auxiliary chamber emergency leaf became damaged, and the chamber was unavailable for ice or drift overpassage until January 19, 1978. At that point, ice had frozen the chamber solid, and a crippled boat was embedded in the chamber.

D. January, 1978

After the low flows of 1976 and continuing into the summer of 1977,

> the weather did a flip-flop and relatively wet conditions prevailed through December. Although precipitation was near normal in December, streamflows averaged considerably above normal because of rainfall excesses during the previous several months. Air temperatures were somewhat above normal in November and below normal in December. Although a new record low of -3 °F was established at Cincinnati for the 6th of December, deviations from normal were not particularly noteworthy for the month as a whole.
>
> Tributary storage reservoirs had been effective in averting moderate flooding in several principal Ohio River tributaries during December. Much of the excess reservoir storage had been released and steamflows were approaching 'normal' by the end of the month. However, below normal temperatures had begun to produce ice, particularly on tributaries. The continued development of ice both on tributaries and along the banks of the Ohio on into January would have to be considered normal for that time of year.

Exhibit 179 at Appendix 1, p. 6.

> During the early part of January, the 1st through the 9th, flows in the Ohio River at Markland Locks and Dam ranged from approximately 100,000 to 200,000 cfs. From the period of 10 through 12 January, the flows increased to almost 270,000 cfs. Then from the 13th through the 25th, the flows decreased from 270,000 to approximately 87,000 cfs. Then from the 25th to the 30th, due to heavy rainfall throughout the Ohio Valley, heavy runoff was experienced; and flows increased from 87,000 to approximately 450,000 cfs.

Id. at Exhibit 6, p. 1.

With that introduction, we turn to close examination of the weather and river conditions for the period January 5-28, 1978, as well as circumstances at Markland and Meldahl Locks & Dams, with additional detail or digression as needed. The primary variables we will address include weather conditions (temperature, precipitation, and forecast); river conditions (including flow at Markland and Meldahl; ice conditions; and river forecasts); lock and dam operations (including gate settings, ice passing activities, and lockages); and general observations as necessary.

1. Conditions Before January 16

Because January 16th — the date when ice conditions began to significantly worsen — presents a natural line of demarcation, we first provide a general view of the conditions on the river prior to that date.

From New Year's Day through about January 7, river flows were slightly below average, but well above the record low flows experienced in 1977. As noted in the Ice Report excerpt quoted above, flows greatly increased beginning about the 7th, and went as high as 250-270,000 cfs by the 12th. From the 12th through the 16th, flows dropped back down, crossing the average mark of about 138,000 cfs on the 16th.

Temperatures at Cincinnati for the same period were somewhat below average, but not as low as those recorded in 1977. The temperature on New Year's Day was approximately 21 °F, with a rise to about 23 °F on the 5th, falling to about 16 °F on the 12th, returning to about 20 °F on the 16th.

Markland's precipitation records (Exhibit 147) reflect that approximately nine inches of snow fell during the first two weeks of the month; of course, subfreezing temperatures prevented the snow from melting, and so it accumulated.

Markland was running between 10' and 30' of gate openings between the 1st and the 8th of January, with between 29,600 and 31,800 cfs being diverted to the hydroelectric plant. Beginning late on the afternoon of the 8th, gate openings were increased to 48 feet, and steadily increased to 120 feet on the 11th and 12th; on the afternoon of the 12th, gate openings were reduced to 108 feet and continued down to 42 feet on the afternoon of Sunday, January 15. During this period, the hydroelectric plant was receiving a constant 23,800 cfs. (This information is gleaned from Exhibit 121, the Markland operations log.)

a. The First Ice.

As part of their standard operating procedure, lock personnel are required to maintain records of their observations of ice conditions. To facilitate ice reporting, the Corps has generated an "ice code," reflected in Exhibit 155. A coded ice report includes five elements: amount (a one-digit number reflecting tenths of river surface covered); type (a letter code reflecting whether the ice is running, stationary, jammed, locally forming, or affixed to the shore); thickness (in inches); "structure" (a letter designation reflecting the physical integrity of the ice); and distance upstream reported in miles. Thus, an ice code "5-A-2-C-1" would indicated (sic) that five-tenths of the river was covered with stationary ice, two inches thick; that the ice was clear; and that it was observed to continue for one mile upstream from the dam.

The first ice coding at Markland appears in the log during the morning of Saturday, January 14. The code is "1-S-½-T-X" — one-tenth of the river covered with shore ice, ½" thick, "rotten," and extending as far upstream as observation permitted. The code for the 15th was "1-R-1-T-X," indicating one inch of rotten ice, extending out of sight, and moving with the current.

The situation at Meldahl was rather more serious during the period from the tenth through the fifteenth than that at Markland.

> Ice was first reported at Meldahl on 10 Jan. 1978. The river was rising due to rainfall upstream of the project. Heavy ice was accumulating on the upstream side of the dam and in the upper approach. The auxiliary lock emergency gate was first placed into operation on 11 Jan 1978 on an as-needed basis to pass ice to keep the upstream approach cleared for navigation. Heavy ice continued to build up on the dam and in the approach and starting affecting locking operations on 12 Jan. The river crested and started to decrease and later that day, ice conditions became more critical in the upper approach. By 15 Jan, it was necessary to continually use the auxiliary lock emergency gate to pass ice. Approach conditions became significantly worse on 16 Jan. . . .

Exhibit 179 at § 3-1. The Meldahl logbook (Exhibit 129) reflects that ice was first observed on the tenth, reported as "5-R-1-B," meaning 50% coverage, running, one inch thick, breaking. The code for the 11th is "7-R-1½-B," meaning that the ice was the same as on the previous day, but covered 70% of the river. On the 12th, the report was 5-R-1 ½-B-X; thus, the ice covered had been reduced to 50% of the river surface, and extended upstream out of sight. On the 13th, the code was "5-R-1 ½-L-X," indicating that the ice was beginning to form into layers, but was still covering only 50% of the river. Those conditions prevailed through the 14th; the code for the 15th reflects

"9-R-1 ½-L-X," indicating 90% coverage, but with ice still running.

As this initial period closes, then, the following had occurred. Ice began accumulating at Meldahl on January 10; the next day, Meldahl's auxiliary chamber emergency leaf was placed into the ice-passing mode (*i.e.*, the mitre gates were pinned into their recesses, and the emergency leaf was hoisted out of its slot in the river bed so that its top was out of the river, but ready to be lowered for skimming operations); and ice passage began on an "as-needed" basis. By the 12th, according to the testimony of Meldahl Lockmaster Raymond Dunaway, ice was running; at least some of it, we conclude after review of Mr. Dunaway's testimony, was being passed through the auxiliary chamber. Ice did not begin to appear at Markland until the 14th, and that was only shore ice; on the 15th, running ice appeared at Markland. However, review of the Markland lock operations log (Exhibit 149) demonstrates that, at least at the times gate openings were recorded, no ice was being passed. Thus, we find that by the 15th, when running ice was reported extending out of sight, the ice was only "running" until it arrived at Markland, at which point it as (sic) stopping and beginning to accumulate.

2. Monday, January 16, 1978

The Louisville[3] forecast for the 16th was accumulation of three to four inches of new snow, with the high temperatures being in the high twenties; a travellers' advisory issued (Exhibit 264 at 45).

At Markland, ice conditions were coded as "8-R-2-L-X" — 80% coverage; running; 2 inches thick; extending out of sight. The entry in the lock log for 0800 hours reflects that the dam was running 42 feet of gate opening, and diverting 23,200 cfs to

[3] We use the Louisville forecast throughout as the best available indicator of the forecast for Markland, some seventy miles upstream.

the hydroelectric plant. The entry also states that "M/V PEGGY MAYS stuck in ice above lock. Ice moderate. . . . Ice gorged from Craigs Creek to Markland Lock. Very heavy ice and snow." The log entry for 1600 reflects, *inter alia,* that hydro plant consumption had been reduced to 20,000 cfs, and that lock personnel were "Washing Ice Through Gat (sic) #3#4#5 from 400 P.M. to 800 P.M." (Exhibit 121 at 1/16 entry). River flow was approximately 138,000 cfs (Exhibit 179, Ice Report, at Ex. 4).

The entry regarding passage of ice through gates 3, 4, and 5 is somewhat perplexing. There was unanimity among the witnesses that ice could only pass under raised gates when those gates were at least 12-14 feet off their sills; government witnesses uniformly testified that Markland personnel were not to raise gates to underflow passage positions unless they either coordinated the process with their superiors in the Louisville District Office, or there was sufficient flow to raise *all* gates 12 feet or more off their sills. Review of the gate-position log for January 16th (Exhibit 122) reflects that as of 8:10 p.m. on the 16th, the dam gates were open a *total* of thirty-seven feet — barely enough to permit ice passage through gates 3-5 with all other gates closed. The situation was not addressed by the Markland personnel who testifed at trial. The possibilities would be that ice was passed over submerged gates; that flow was concentrated between the three gates mentioned; or that the entry is in error. We are, by virtue of the lack of testimony on point, unable to find that one or the other of the events occurred; we simply note that the question exists. At any rate, the documents do not suggest that any substantial amount of ice was passed through the gates.

John Ryle, Assistant Lockmaster at Markland, testified that the ice on the 16th was "big sheets of ice," but that it was still "running." Again, we observe that the government does not aver that (perhaps other than during the four-hour period noted in the log, which cannot be reconciled with Corps procedures

and flow levels), ice was being passed through Markland during this time; we thus conclude that the ice was "running" only as far as the Markland project, where it was stopping as it came against ice already built up from the dam. Mr. Ryle also testified that he had no personal knowledge regarding the notation of a gorge between Craig's Creek (located about three miles upstream from Markland) and the dam.

In short, the picture regarding conditions at Markland on the 16th is not completely clear. However, based upon the entries in the log, as well as Mr. Ryle's testimony, we conclude that as of that date ice had accumulated in significant quantities, and that it was running down as far as the structure and then building back upstream as it stopped against the dam. However, it appears that there was still movement in the ice within visual range of the dam, in that it was reported as "running."

Conditions at Meldahl on the 16th were significantly worse than at Markland:

> Approach conditions became significantly worse on 16 Jan and two tows became trapped and were unable to maneuver in the ice pack which now extended 8 to 10 miles upstream of the dam. Passing of ice was stopped to prevent drawing the trapped tows down onto the dam and the Lockmaster requested all other downbound tows to stay upstream of the ice pack until a channel could be cleared. This action was taken to prevent additional tows from becoming trapped in the ice pack. The situation could be summarized as follows: traffic not moving; river flows decreasing; ice pack continuing to expand; and temperatures staying well below freezing. Because of these conditions, a decision was made that a method of operation had to be developed and implemented to maintain navigation once the two trapped tows were freed. The method of operation adopted consisted of using volunteer commercial towboats both in the upper approach and

> upstream of the dam to continually work the ice. This ice was then passed continually through the dam tainter gates and through the auxiliary lock emergency gate. This method of operation proved successful in maintaining navigation and was used during the balance of the adverse ice conditions at Meldahl.

Ice Report, Exhibit 179 at Exhibit 5, p. 3-1. The Meldahl log entry for the 16th reflects the following. Ice code: 8-R-2-L-X (80% coverage, running, 2" thick, layered, extending out of sight). The temperature ranged from 2° to 15°F. Throughout most of the day, the dam ran 47 feet of gate opening, spread evenly across 12 gates. However, the 11:15 p.m. entry reflects that the gates were manipulated into an underflow ice passage configuration: Gates 1, 2, and 3 closed; gate 4, 3 feet; gate 5, 7 feet; gates 6 and 7, 10 feet; gate 8, 4 feet; gate 9, 3 feet; gate 10, 4 feet; and gates 11 and 12, closed.

Markland locked nine vessels upstream into the Markland pool, and one vessel downstream into the McAlpine pool (Exhibit 140). Meldahl was able to lock only two upbound and one downbound tow (Exhibit 129).

On the 16th, then, the situation was as follows. Meldahl was continually skimming ice through the auxiliary chamber, and was beginning to use underflow passage configurations on the dam gates. In addition, Meldahl Lockmaster Dunaway had developed "a method of operation . . . to maintain navigation" through the lock. That method was as follows. Vessels were asked by the lockmaster to participate in activities designed to keep ice moving through the auxiliary chamber and through the dam. The vessels were instructed to " '[p]ut the head of [their] tow[s] in against the [Ohio] bank, this hill, and try to shove it to Michigan' " (Dunaway Depo. at 166). In less scientific parlance, the boats were to nose into the bank and accelerate their engines. The effect of this strategy was that the turbulence caused by the revving propellers ("wheel wash") served to

aereate the water, and to create turbulence sufficient to break up ice immediately upstream from the structure so that it could pass through into the Markland pool. The lockmaster also had another vessel policing the downstream aspect of the structure, using its wheel wash to prevent ice from being carried back upstream by prevailing upstream winds.

3. Tuesday, January 17, 1978

The Louisville forecast on the 17th was for

> [h]eavy snow today . . . [sic] An additional four or more inches of snow with a total depth of snow 18 [to] 20 inches by this afternoon . . . Highs today in the upper 20s.
>
> Snow tapering off to flurries tonight with the lowest near 20 degrees.
>
> Becoming partly cloudy and continued cold Wednesday . . . high near 30.
>
> Winds . . . Northeast 10 to 15 MPH gusting to 25 MPH during the afternoon becoming northerly tonight.

River flow at Markland on the 17th was 110,300 cfs — down approximately 20,000 cfs from the 16th. Snow cover at Markland has accumulated to 9 inches, and the ice code for the 17th was "8-R-2-L-X" — 80% coverage, "running," 2 inches thick, layered, and extending out of sight of the dam. Gate openings across the dam were down to 35 feet at midnight, decreasing to 29 feet by 0800 and 27 feet by 1601 hours. The log entry beginning at 8:00 a.m. reflects that ice was "very [sic] heavy," and that the M/V JESSIE BRANT took nearly seven hours to lock through the main chamber. The entry beginning at 4:00 p.m. reflects that efforts were being made to wash ice through the main chamber; Mr. Ryle testified that the attempt was to have a vessel push as much ice as it could into the chamber; the chamber level was lowered to lower pool level, and the ice was locked through; the chamber was rewatered, and the

vessel then locked through. There was agreement that this is the least effective procedure of all those ice passing possibilities involved in the structure. Again, we note our observation that while the ice code reports "running" ice, the exhibits reflect that, with the exception of the ice which was passing through the main chamber ahead of a vessel, ice was only running down as far as the dam, where it was stopping against, or running up under, ice which had already stopped at or short of the structure.

The river flow and velocity forecast for the days following the 17th were for continuing declines, with the predicted flow for the 18th and 19th being 94,600 and 88,900 cfs respectively.

At Meldahl, the 17th was a day of continued ice difficulties. The ice code was "10-P-3-L-X" — 100% coverage, stopped, 3 inches thick, layered, out-of-sight — in the morning, and "10-P-4-L-X" — an inch thicker — later in the day. The low temperature was 3°, the high 25°. At 3:00 p.m., the dam gates were manipulated into underflow ice passage configuration — gates 1-5 closed; gates 6-8 raised 12 feet each; gates 9-12 closed; the gates were readjusted so that the openings were distributed evenly across the dam by 6:00 p.m.

Thus, on the 17th, Meldahl was passing ice "constantly" through the auxiliary chamber; there was only one tow locked through Meldahl locks on the 17th, and so the auxiliary chamber was available for virtually all of that date. In addition, Meldahl was passing ice through its gates during at least one period on the 17th.

At Markland, ice was coming down from Meldahl and running as far as the project. Tows were still able to transit the locks, although in small numbers (three upbound and one downbound), and ice conditions were worsening. The record does not reflect that Markland personnel were taking steps to prepare for, or seriously considered, the possibility that ice conditions would continue to worsen, despite the predicted continu-

ing cold weather and the fact that Meldahl was continually passing additional ice into the Markland pool.

4. Digressions.

At this juncture, we briefly consider three topics: pool surveillance, Corps of Engineers organizational hierarchy, and ice formation and characteristics.

a. Pool Surveillance.

As briefly noted above, the ice operations directives (*e.g.* Exhibit 113B) distributed during the 1950s specifically provided for establishment of "ice patrols" to monitor the formation and conditions of ice in each structure's pool (the reach of river between a structure and the next structure upstream). Similarly, the January 23, 1978 "ice plan" (Exhibit 113A) opens with the instruction that "[d]uring the period of cold weather, Lockmasters shall observe closely the formation of ice in their pools . . . ." The purpose of such patrols is obvious; without it, those at a given project — as well as their superiors, for whom project personnel are the principal means of gathering information — are unable to understand conditions more than a few miles upstream of the project, and are thus handicapped in assessing conditions as they develop and in planning for contingencies which might be reasonable predictable.

At Markland in 1978, actual surveillance existed only by way of dam personnel standing on the structure itself and using their naked eyes or binoculars to view the stretch of the river visible therefrom. During trial, we visited the Markland project; because the structure sits at the foot of a bend, visibility is limited to the stretch of the river just above where the bend starts to sweep left (looking upstream) — a distance of some one and one-half miles (*see* Exhibits 333 at 1; 302F). Lockmaster Sheldon testified that his home is twenty-two road miles from Markland, and that he would observe the pool when driving to or from work; however, the road leaves the river for much of

that distance, and Mr. Sheldon's work schedule was such that his only opportunity to observe the river during daylight was on his way home in the afternoon. In addition, as we discuss *infra,* from January 21st on, he lived at the structure full-time, and was thus never able to observe the pool upstream of the bend above Markland.

Other means of gathering information were listening to radio broadcasts from towboats coming downstream. Mr. Sheldon testified that his transceiver at the project would receive transmissions from tows up as far as Big Bone Island, some fifteen miles upstream, under certain weather conditions, but could only send messages about three miles upstream. Other witnesses thought with Mr. Sheldon's assessment of the range of the radios at the project conservative, but at any rate, transmission outside the general vicinity of the dam was impossible. Further, Mr. Sheldon testified that he discounted information received by radio from towboats (Tr. I at 782); he did not testify that he routinely contacted towboats coming downstream to gain information regarding conditions in the pool. In sum, we find that simply monitoring the radio conversations of towboats was not an effective way of monitoring ice conditions in the pool as they developed, particulary as the Lockmaster himself did not consider the source to be especially reliable.

The surveillance picture at Markland, as is true of many aspects of this case, compares unfavorably with that at Meldahl. Lockmaster Dunaway testified that he routinely drove upriver to at least the midpoint of the Meldahl pool "[f]or peace of mind . . . you want to see what's going on. I like to see what's going on above, you know? You know, coming down the river." In addition, personnel from the Huntington District of the Corps, which oversees operation of Meldahl and other dams on up to Pittsburgh, conducted overflights of the river in order to get a better picture of what was going on in the various pools; Mr. Dunaway was supplied information generated during those flights.

Thus, Markland personnel, the record reflects — and we so find — made only minimal efforts to find out "what's going on above;" they were not well-informed as to the extent of the ice passage occurring at Meldahl, and they were uninformed as to the extent of ice collecting and forming in their pool, even just a few miles upstream.

b. Corps Hierarchy.

We piece the following together from the testimony of a number of Corps witnesses. Defendant initially proffered, but did not offer into evidence, Exhibit 501, a Corps organization chart; however, as it was not admitted, we do not utilize the exhibit.

The senior official in the Corps, the Chief of Engineers, is at present General E.R. Heiberg. Under the Office of the Chief of Engineers come Division Offices; the Division relevant to this case is the Ohio River Division (ORD), centered in Cincinnati, Ohio. At all times directly relevant to this case, General Heiberg was the senior official in charge of the ORD. Under the Division come District Offices, two of which are relevant to this case. The Huntington (W.Va.) District has responsibility for, *inter alia,* six Corps-owned structures on the Ohio River from Meldahl Locks and Dam upriver. The Louisville (Kentucky) District has responsibility for, *inter alia,* all Corps-owned projects from the Markland pool (*i.e.,* from the downstream side of Meldahl) down to the confluence of the Ohio and the Mississippi.

The ORD is comprised of a number of subunits. Examples are the Engineering Branch; the Hydrology Branch; the Construction Operations Division; the Reservoir Control Center; and others. As we understand it, each of these organizations is responsible for oversight functions of analogous subdivisions at the District level.

Each District office has primary responsibility for the operation of projects within its jurisdiction. Of course, the Corps has

a myriad of activities other than operation of locks and dams. At the District level, general operational and oversight functions are performed, and those are transmitted to the projects for implementation. Thus, there is of necessity substantial autonomy as between the District offices, and the primary role of the Division offices is to oversee budgetary and policy matters and to coordinate activites between the Divisions, as well as to provide practical and policy-related guidance to the District offices. Of course, given this hierarchy, the District offices have the authority to direct, and override, the project personnel; the Division office has the authority to direct and override the Districts; and the Office of the Chief of Engineers has the authority to direct and override the Divisions.

c. More Ice.

We have not, as yet, examined the wealth of evidence offered by expert witnesses regarding the formation, characteristics, and dissipation of ice on the river. Much of the evidence adduced is of value primarily as background, and is not discussed here; however, it is important to consideration of the issues to have a basic grasp of the ultimate agent involved in this litigation, and so we examine the ice evidence briefly.

The principal ice witness for petitioners was Mr. Samuel S. Lazier; Hans Kivisild, Ph.D., offered brief testimony discussed in the context of the B-R River Services case, *infra*. The government's principal witnesses on ice-related matters were John F. Kennedy, Ph.D., Guenther Frankenstein, Ph.D., and George Ashton, Ph.D.

(i) Mr. Lazier

Mr. Lazier, who testified on three separate occasions, is a Registered Professional Engineer in the Province of Ontario and a full Professor of Civil and Mechanical Engineering at Queen's University, Kingston, Ontario. Since at least 1951, Mr. Lazier has been involved in the hydraulics of rivers. He worked

for several years with problems relative to floating cut pulpwood downriver from Canadian forests to processing mills, and has worked specifically in the subspecialty of "ice engineering" for about twenty years; he has published a number of articles in the field (*see* Exhibit 295, Mr. Lazier's *curriculum vitae*). It is, we think, fair to characterize Mr. Lazier as one of the pioneers in the field of ice mechanics. Mr. Lazier was accepted by the Court as an expert in hydraulics, hydrology, and ice engineering.

We excerpt at some length Mr. Lazier's explanation of how ice forms and dissipates:

> The term that's normally associates with ["slush"] ice . . . is frazil ice, and that is . . . the first manifestation of ice. It's sort of embryo crystals.
>
> [Frazil ice] has a specific gravity like water, so it, therefore, it can be carried through the water. It doesn't necessarily float. It may float or it may be at the bottom and it is very sticky. It sticks to anything. Put your finger in it, you'll come out with it, and a load of ice on the end of one's finger, and it particularly sticks to metal protrusions, gates, trash racks and so forth particularly at powerplants and can obstruct a powerplant in fact.
>
> * * *
>
> [The next stage of ice formation is called brash ice, which is] a mixture of frazil ice, small particles of ice and usually fairly soft and also includes sizeable pieces. In the case of the river, in the case of the Ohio, they may be several feet in size, but in a smaller river they'd only be a few inches. And it has a great deal of cohesion because of all of this frazil ice that's mixed in it; and whilst it isn't sticky, it is certainly more cohesive than individual blocks of ice.
>
> * * *

> The initial formation is frazil ice, then the frazil ice agglomerates into crystals which are very long and that is called black ice and that is the strongest known type of ice there is, and it's black because when you stand on it and look through it, it doesn't look to be there. You can see right through the ice right to the bottom of the river if the visibility is good.
>
> Then from then on ice begins to deteriorate through a metamorphosis, and as the sun gets at it and the warm weather gets at it the crystalline form changes from the long lines into smaller crystals. That ice gets refrozen and becomes a heterogenous material, and then in the final phase . . . it become candled. And if you take a chunk of ice out, it will look like a handful of candles. . . . By that time the ice is just about ready to return to its original state.

Tr. I at 368-70.

Much of the first segment of Mr. Lazier's testimony pertained to a calculation which results in a number which correlates with the tendency of ice in a stream to begin jamming:

> [I]t's call[ed] the 'Froude Number,' and mathematically it's the velocity of the flow, usually in feet per seconds in English units, the velocity of the flow divided by the square root of the depth of water, some mean depth usually, and also divided by the square root of the acceleration of gravity.

Tr. I at 321. We do not reproduce the precise formula here, nor do we detail the mathematical calculations beyond this basic explanation. However, the Froude number calculations has been, Mr. Lazier testified, found to correlate at a certain critical value with the formation of ice jams. That critical value is approximately .08.

What this means, as we understand Mr. Lazier's explanation, is this. When velocities in the river are relatively low, ice which is being carried downstream will simply bump into whatever obstacle it comes into contact with — here, either Markland Dam, or ice built upstream from Markland — and stops. Thus, while it will tend to build upstream if it is not allowed to continue through an obstruction, it will not build up above or down below the surface of the ice which is ahead of it, and so no jamming — vertical blockage of the channel — will occur. However, when velocities increase, the existence of an ice cover adds a compression factor to the water coming downstream, and ice carried with that water; as the ice extends at least a little bit beneath the surface of the water, water coming downstream must go under the ice, and because the vertical space is smaller, the water increases in velocity. As it increases in velocity (and bearing in mind that it is, by hypothesis, already moving at an increased velocity), it will pull ice carried with it under the existing ice cover. However, agglomerated ice floats; once the moving ice tries to get back to the top of the water, it bumps into — and can become attached to — the existing ice cover. The net result, of course, is that the existing ice cover gets thicker.

The process is a synergistic one. As the ice cover extends more deeply into the channel, the velocity of water passing under it must increase, causing more ice to come under and eventually adhere to the underside of the ice cover. In turn, the ice coming up against the bottom of the ice cover is subjected to greater hydraulic force, and it compacts and melds into the ice cover, creating, instead of a number of adjacent floes, a homogeneous mass of ice.

The next element to be introduced is the character of the channel. The amount of water coming downstream is, of course, a constant as between two linear points in the channel. When the channel narrows, or when an obstacle cuts off part of the width, then the water must move faster to "squeeze through" the narrowing space.

After these phenomena continue for a period, then it becomes a jam, restricting or completely blocking the flow of water downstream:

> This obstruction here increased the water level upstream because previously we were flowing down under gravity at this velocity. Now we have a high velocity under there and much higher forces than we had on the bottom before. And so in order for this flow to be accommodated, the water level has to rise . . . .
>
> So this jam causes a water level rise. Now, the deeper this jam gets — in other words, as the more and more blocks come down and deepens it and it compacts, the higher will be this rise.
>
> Now, in a deep river like the Ohio, the possibility of this extending to the bottom is very, very slim indeed. In narrow channels, in shallow channels, sometimes a jam will form like this (indicating), then the flow will go down and the whole river level drops including the ice and the ice then grounds. I can't see that happening in the Ohio. There's 30 feet of water almost everywhere at least, and so there's also water flowing under the jam, but of course because of the increased friction, the water level is higher upstream, the energy's got to come there to overcome this friction.

Tr. I at 331.

Thus, the import of Mr. Lazier's testimony is that when river flows increase, an ice cover exists, additional ice comes downstream with the fast water, and there is an obstruction or narrowing of the channel, jamming is foreseeable. These principles are mathematically modelled in Mr. Lazier's report, Exhibit 228B.

(ii) Dr. Kennedy.

Dr. John Kennedy testified on behalf of the government. Dr. Kennedy is Carver Distinguished Professor of Engineering at the University of Iowa, and is founder and director of the Iowa Institute of Hydraulic Research. He teaches and consults in the field of ice engineering, and lists among his consulting clients the Bechtel Construction Company, the St. Lawrence Seaway Development Corporation, the People's Republic of China, the government of Pakistan, and, of course, the Corps of Engineers. He was retained by the Kentucky Attorney General's Office to assist in implementation of the decision of a Supreme Court-appointed special master arbiting the Ohio-Kentucky border dispute, and thus gained familiarity with the Ohio River.

As relevant to this preliminary discussion, Dr. Kennedy testified that ice jams are less predictable than Mr. Lazier believes. Dr. Kennedy testified that the Froude number analysis is a useful tool, but must be considered in the context of other factors; he also testified that the .08 critical Froude value accepted by Mr. Lazier is susceptible to challenge. As to the predicates for an ice jam, he testified that they are: (1) a supply of ice; (2) hydraulic and ice conditions which cause submergence of ice coming downstream; and (3) overriding flows and subsequent channel blockage. He did agree with Mr. Lazier, however that the highest probability for jams exists at points of "nonuniformities" in the channel, *e.g.*, islands, shoals, curves, or places where the channel narrows.

With this general introduction to the concepts of ice formation and the interrelation between flow, channel, and ice, we return to our chronology of events. The testimony of Dr. Kennedy and the government's other ice experts will be taken up once later events at Markland are fleshed out.

5. Wednesday, January 18.

The Louisville forecast on the morning of the 18th was for

> Generally cloudy but with brief clearing this afternoon and tonight. High today near 30. Lows tonight in the mid teens.
>
> Increasing cloudiness with a slight chance of snow showers Thursday high Thursday near 30 degrees.
>
> Winds . . . northwest 5 to 10 mph today . . . light northerly tonight and northeast 10 mph Thursday.

The forecast for Wednesday afternoon had changed for the worse:

> ..... Winter storm watch Thursday and Thursday night ..... Mostly cloudy tonight ... low 15 to 20. Cloudy with snow likely beginning during the day Thursday and continuing Thursday night and Friday. Snow possibility becoming heavy at times. Highs Thursday and Friday in the upper 20s. Low Thursday night in the low 20s.

Exhibit 264 at 39-40.

At Markland, the ice code was reported as "10-S-4-L-X" — 100% coverage, 4 inches thick, layered, out-of-sight. The "S" in the code would correspond to the designation for "shore ice;" however, because the definition of shore ice is wholly incompatible with 100% coverage of the river, we conclude that the "S" actually reflected that the ice was stopped.

The Markland log reflects that the dam was running only nineteen feet of gate opening, and the power plant was utilizing 29,200 cfs. There was a twelve-inch snow cover at the project, and the log reflects that the project crew was attempting to break ice in the auxiliary lock chamber (Assistant Lockmaster Ryle testified that the attempt was likely carried out with the dam's pusher boat). The log reflects "[i]ce cond[itions] very bad it takes 2 or 3 boats to push tow through ice." (Exhibit 121 at January 18th.) River flow on the 18th at Markland was 97,100 cfs, some 3,000 cfs over what had been predicted on the

17th. Flows were predicted to continue declining through the 20th. (Exhibit 219 at 01/18/78 entry.) Markland locked three upbound and two downbound tows through the main chamber (Exhibit 122).

The entry regarding the breaking of ice in the auxiliary chamber is noteworthy. It was on the 19th — after the auxiliary chamber had frozen up — that the new auxiliary chamber upstream mitre gate latch pin was installed; as discussed above, the ability to pin back the mitre gates is crucial to use of the emergency leaf for skimming operations, and one of the pins had been broken since 1976. Thus, it may have been that the Markland crew was, once the latch pin was in place, attempting to render the auxiliary chamber ready for ice-passage procedures. However, since the onset of ice conditions, the project's work boat had been moored in the auxiliary chamber, and had become frozen into the ice; its presence, of course, prohibited the chamber's use for passing ice. Assistant Lockmaster Ryle was unable to testify as to conditions on the 17th, as he was not working. However, he testified both that the only way he knew of to break ice in the auxiliary chamber was with the pusher boat (Tr. I at 470-71) and that the ice in the auxiliary chamber was "froze solid" and "we couldn't have" successfully broken it with the pusher boat or otherwise (*Id.* at 462).

Thus, conditions at Markland continued to deteriorate. Lockage was slow, and ice was "very bad." However, neither testimony nor exhibits suggest that the Markland crew was attempting to implement practices designed to ameliorate the situation, with the possible exception of the ice-breaking attempt.

At Meldahl, the ice conditions were coded as "10-R-5-L-X" — 100% coverage, running, 5 inches thick, layered, out of sight. Temperatures ranged from 10° to 24°. The dam ran from 23 feet to 31 feet of gate throughout the day, and at 4:30 p.m., the dam gates were replaced in an ice-passing configura-

tion: gates 1-4 and 8-12 closed; gate 5, 7 feet; gates 6 and 7, 10 feet each. The 4:30 notation indicates "emerg gate," reflecting continued ice passage through the auxiliary chamber. Markland was able to lock six tows, all downbound (Exhibit 129 at 1-18-78). From the 17th on at Meldahl,

> [n]umerous volunteer lite boats [*sic.;* towboats without barges] were now operating in the ice pack trying to reduce the pack density. Formation of a defined channel was virtually impossible due to the slushy nature of the ice and the only alternative was to reduce pack density. Conditions were essentially static with reduced flows and a heavy ice pack for the period extending from the 18th through the 24th. Through this period, ice was passing through the dam and the auxiliary lock utilizing the emergency gate.

Exhibit 179 at 3-1.

6. Thursday, January 19.

The Louisville forecast on the morning of the 19th was for

> ... Winter storm warning today and tonight ...
>
> Light snow mixed with occasional freezing rain or sleet today becoming moderate to heavy snow tonight and ending as flurries on Friday. Total accumulation of new snow 3 to 6 inches. High today near 30. Lows tonight near 20. High Friday in the upper 20s.

Again, the afternoon forecast was somewhat worse:

> ... Heavy snow warning this afternoon and tonight ...
>
> Snow this afternoon and tonight ... heavy at times ... possibly accumulating from 4 to 6 or more inches of new snow by Friday morning. High this afternoon in the upper 20s. Low tonight near 20. Mostly cloudy Friday with chance of snow showers. High in the upper 20s.

Exhibit 264 at 33-34.

Markland's ice code as "10-S-4-L-X." The dam was running 19 feet of gate opening, and the hydro plant was taking 27,200 cfs. The log entry indicates to activities related to ice passage efforts (Exhibit 121 at January 19). The operations log indicates that at midnight, ages 1, 7, and 8 were closed; gates 2-6 and 12 were open 2 feet each; and gates 9-11 were open 3 feet each (for a total of 21 feet). The 8:00 a.m. gate report indicates that gate 2 had been closed to provide the 19 feet reported in the main log (Exhibit 125 at January 19).

River flow on the 19th at Markland was 99,500 cfs (Exhibit 219 at 01/19/78), and the project was able to lock two downbound and eight upbound tows (Exhibit 122).

Conditions at Meldahl were, as noted in the previous entry, relatively static. The ice code was "10-R-5-L-X;" temperatures ranged from 11° to 26°; the emergency gate was in use for passing ice; and the gate operations entries show that the gates were in an ice-passing configuration for the entire day, although only 27-36 feet of gate opening was available due to low flows (98,700 cfs). Meldahl was able to lock five upbound and no downbound tows; the last tow to start locking through took over six hours to lock through.

Markland Lockmaster Sheldon testified that during this period, he wanted to use the main chamber to pass ice more than was done (*i.e.*, more than the one attempt to do so reported above), but "[w]e didn't get an attempt made because we still was being pushed to lock. That was our main object." (Tr. I 716). He agreed that due to the low flows, his perception was that it was not possible to pass ice through Markland (*id.* at 702), and agreed with petitioner's counsel that "you simply were not moving ice through Markland Dam" (*id.* at 717).

7. Friday, January 20.

Friday's forecast was for cold with a few flurries continuing into Saturday, with temperatures between 15° and 25°. The

Markland log shows the ice code as "10-R-4-L-X;" again, based upon the exhibits and testimony, we find that ice was not running through the dam, as the code might be interpreted to suggest, but was only running, at most, down to the structure and then stopping. The gate log (Exhibit 149) shows gate openings of approximately three feet across the dam; river flow was 102,600 cfs, up at 3,000 cfs from Thursday; total gate openings were 21 feet-23 feet. Snow cover was reported at 12 inches, and the log reflects that it was "very difficult to lock boats" (Exhibit 121). On the 20th, because of the existence of difficult ice conditions, Markland personnel went to 12-hour shifts (*id.*).

At Meldahl, the ice code was "10-R-5-L-8.5" (Exhibit 129) — indicating that surveillance had revealed that the ice extended 8.5 miles upstream from the structure. Temperatures ranged from 14° to 25°. The log reflects that Meldahl's dam gates were in full ice-passing configuration for the whole day: At midnight, gates 1-3 and 6-12 were closed, and gates 4-5 were open 18 feet each; at 9:00 a.m., gates 1-2 and 6-12 were closed, and gates 3-5 were open 14 feet apiece; at 1:45 p.m., gates 1-2 and 6-12 were closed, gate 3 was open 12 feet, and gates 4-5 were open 14 feet apiece. The log reflects "[i]ce thru dam."

Meldahl locked three tows up and one down; Markland locked five tows up into the Markland pool.

a. The Carigan Request.

While the 20th was a relatively uneventful day at the dams (although hardly business as usual), a noteworthy series of events occurred behind the scenes. As memorialized in the Ice Committee Report:

> Due to adverse weather conditions, the Huntington District Office was closed on Friday, 20 Jan 1978. Mr. Ken Crisp, Chief, Operations Division, received a telephone call from Mr. Pat Carigan, Chief, Construction-Operations Division, ORD, at approximately 10:30 AM re-

> questing the Meldahl be instructed to stop passing ice. Discussion of the past Meldahl actions and correct methods of operation to maintain navigation ensued. While Messrs. Crisp and Carigan were having their discussion, Mr. Humphrey of ORD called Meldahl to solicit on-the-scene information concerning the ice situation as it would apply to the discussion being had by Messrs. Crisp and Carigan. Mr. Hayes, Area Engineer, who had been dispatched from the District Office on 19 Jan to provide on-the-scene engineering assessments and assistance, received the call. Mr. Hayes conveyed an accurate and detailed verbal assessment of the existing conditions and prognosis of the Lockmaster and himself as to the potential effects of stopping this ice. Mr. Humphrey agreed to this assessment. Based on the joint evaluation of the situation existing at Meldahl and the demonstrated success of the method being used, it was agreed to continue the operation without modification. The Lockmaster at Meldahl was so instructed.

Exhibit 179 at 3-2.

At trial, Mr. Carigan testified that he had received a call from Norbert Whitlock, Chief of Operations for the Louisville District, to the effect that Markland was being "covered up with ice" (in Mr. Carigan's words), and that if Meldahl stopped passing ice, then Markland could clear some of its ice out. Mr. Carigan agreed with the Ice Report statement; he called Mr. Crisp and explained Mr. Whitlock's perception that ice passage through Meldahl was causing problems at Markland, and asked Mr. Crisp to "do what he could to alleviate it." However, Mr. Crisp informed Mr. Carigan, according to Carigan's testimony, that his responsibility related to structures in his [Huntington] District, and Meldahl personnel were doing what they should — and would not change their operations, in light of their success at handling their problem. Mr. Carigan testified that he was aware that Meldahl was using the emergency leaf, tainter gates,

and industry tows to break up ice and move it downstream. He also testified that while he had oversight responsibility for both Districts — and hence could have required Meldahl to stop passing ice — he merely made a "request . . . to see if they couldn't hold some of the ice."

The following colloquy occurred at Lockmaster Dunaway's deposition:

> Q. Did you know that a request had been made by the Ohio River Division to Mr. Krist [sic] that Meldahl be instructed to stop passing ice on Friday, January 20, 1978?
>
> A. I don't remember the date but I remember hearing about the request. The request was not directed to me.
>
> Q. Were you consulted?
>
> A. Yes, by my area coordinator. I think he was at my project [Meldahl] at that time, I believe.
>
> * * *
>
> Q. What was the essence of your involvement in the decision with respect to the request made that Meldahl be instructed to stop passing ice on January 20, 1978?
>
> A. My involvement was that my area coordinator asked me what I thought about it and I said you have one alternative — two alternatives, I guess. You either stop the ice; if you stop the ice, you suspend navigation. If you pass the ice, you maintain navigation.
>
> We were being pressured by the towing industries, we were being pressured by the cities for salt, we were being pressured by the cities for petroleum. So, whoever made that decision I'm sure took that into consideration.
>
> Q. What was your recommendation?
>
> A. I made no recommendation.

Dunaway Dep. at 143-45.

Markland Sheldon Lockmaster was not questioned, at trial, regarding his knowledge of this request from his superior, Mr. Whitlock, to cut back the flow of ice from Meldahl. He did, however, testify as follows:

> Q. . . . Mr. Sheldon, in January of 1978, were you familiar with a procedure utilizing towboats wherein towboats would be positioned above the lock facing the bank and directing their wheel wash into the approach area to move the ice riverward away from the entrance to the locks?
>
> A. Yes, sir.
>
> Q. Had you ever done that?
>
> A. No, sir.
>
> Q. Were you aware that they were doing that at Meldahl during a period of time beginning, say, two weeks prior to the breaking of the gorge [on January 28, 1978]?
>
> A. No, sir.

Tr. I at 798. From this testimony, we conclude that whether or not Mr. Sheldon knew that his superior, Mr. Whitlock, had initiated an attempt to hold ice coming down the main stem from Meldahl, the intelligence regarding Meldahl's operational techniques never made it down the line to Mr. Sheldon. So, too, Mr. Dunaway testified that he "wasn't aware of the problems at Markland."

We view these events and bits of testimony as important in three regards. First, they indicate that there was a lack of communication and oversight control between the Louisville and Huntington Districts in the Ohio River Division. Our perception at trial was that there is a great deal of autonomy given to the District offices, for what are undoubtedly good reasons.

However, the events of January 20 indicate that the lockmaster at Meldahl did not know what was going on at Markland, that the lockmaster at Markland did not know how ice was being passed at Meldahl, and that the Division personnel were unwilling to override the decision of District personnel in Huntington to maintain operations at Meldahl, although the Division personnel had better knowledge regarding the problems those operations were causing downstream.

Second, we credit Mr. Dunaway's testimony that halting ice-passage activites would likely result in suspension of navigation due to ice buildup, a point which calls into question Mr. Sheldon's view that attempting to pass ice would detract from his ability to continue navigation.

Third, these events also indicate that the Corps was aware, certainly no later than the twentieth, that ice conditions at Markland were becoming severe, with no relief in sight.

8. Saturday, January 21.

The forecast was for partly sunny conditions with snow flurries. Lows were expected to be 5-10°, with highs in the upper 20s to low 30s.

The Markland ice code was "10-P-4-L-X;" the "P" stands for "stopped." The log states "[h]eavy ice difficult to lock." The dam was running 31 feet of gate openings, evenly distributed across the gates; the power plant was receiving 27,000 cfs of flow. The afternoon entry states that lock personnel were "[w]ashing ice and locking boats" and "[b]reaking ice in aux[iliary] lock with pusherboat" (Exhibit 121). Three downbound tows were locked.

The Meldahl ice code was not reported. Temperatures ranged from 16-26°. Meldahl's dam gates were in ice-passing mode at all log entries, and Lockmaster Dunaway engaged in an activity he referred to in testimony was "walking" the dam gates. The gate adjustments were as follows:

Time	Gate	1	2	3	4	5	6	7	8	9	10	11	12
midnight		- - -	- - -	14'	14'	12'	- - -	- - -	- - -	- - -	- - -	- - -	- - -
noon		- - -	- - -	12'	- - -	- - -	12'	14'	- - -	- - -	- - -	- - -	- - -
2:00 p.m.		- - -	- - -	6'	- - -	- - -	16'	16'	- - -	- - -	- - -	- - -	- - -
8:00 p.m.		- - -	- - -	6'	16'	16'	- - -	- - -	- - -	- - -	- - -	- - -	- - -

(Exhibit 129 at January 21). According to Mr. Dunaway,

> [i]t's walking the gates. I'd use one gate for a while, the same amount of footage. If the ice would stop at a particular gate, say Gate No. 4, I would move this particular opening over to 5. If I had ice that looked like I'm going to be packing at 11, I would close off 4, move over to 11, put the same amount of opening on 11, just try to make — keep it even across the dam because it would have a tendency to wedge.

Dunaway Dep. at 24-25. Mr. Dunaway testified that he utilized this method of gate manipulation throughout the period of heavy ice, often doing it for only a few minutes to start the ice moving again (*id.* at 25-26); due to the short periods sometimes involved, he testified, many of these "walking" manipulations do not show up in the records (*id.*).

9. Sunday, January 22.

The forecast for Sunday was

> [c]onsiderable sunshine but cold today. High in the upper 20s. Partly cloudy tonight . . . low 15 to 20. Partly sunny; and a little warmer Monday. High in the low to mid 30s.

(Exhibit 264 at 23.) The experience for Monday was for "[i]ncreasing cloudiness with a chance of light snow Monday night . . . lowest temperature in the low 20s." For Tuesday; "[c]loudy and warmer with a chance of rain or snow." *Id.* at 22.

The Markland log entry for midnight to noon on the 22nd reflects an ice code of "10-P-4-L-X." The entry states that the crew was "[w]ashing ice through main locks cleaning snow from lock walls and steps. Cleaning pusherboat off and breaking ice in aux locks." The noon-to-midnight entry is "[w]orking 12 hours shifts Locking *Boats* Washing ice through main lock." Exhibit 121 (emphasis in original). River flow was 107,900 cfs (Exhibit 219 at 1/22/78); the dam ran 23-27' of gate opening and diverted 27,200 cfs to the hydroelectric plant. Two tows were locked.

At Meldahl, temperature ranged from 10 to 37; again, no ice code appears. Meldahl's dam gates were in ice-passing configuration for the entire day. Meldahl was able to lock eight or nine vessels, seven downbound and one or two upbound (Exhibit 129).

10. Monday, January 23.

Forecast, 5:30 a.m.:

> Sunny and warmer today with highs in mid 30s. Increasing cloudiness and warmer tonight with lows in low to mid 20s. Cloudy and warmer Tuesday with rain developing by afternoon. Highs [Tuesday] in low 40s.

Forecast, 4:45 p.m.:

> .... Winter storm watch .... Increasing cloudiness tonight with lows in the low to mid 20s. Light snow changing to sleet and freezing rain Tuesday becoming rain late in the day high near 40. Rain Tuesday night lows in the upper 30s. Wednesday ... colder with rain changing to snow ... highs in the 30s.

Exhibit 264 at 18-20.

At Markland, Monday presented more of the same. The log reflects that the crew was "washing ice through main locks and

assisting in locking of boats. Clearing ice from gate recesses." The dam was running 21' of gate openings in the morning, and 20' in the afternoon; the log reflects 27,200 cfs discharge to the powerplant from midnight until noon, and 35,200 cfs beginning at noon (a number which will remain constant for several days). Three tows were locked downbound.

At Meldahl, temperatures ranged from 6 to 34. Gates were maintained in ice-passing positions. Three downbound and eight upbound tows were locked.

11. Conditions at Other Projects.

At other dams along the Ohio, ice problems were, of course, in existence throughout the period under examination here. At this juncture, we insert Table 2, which consists of data provided in defendant's proposed findings, reproduced in different form:

TABLE 2: LINEAR ANALYSIS OF ICE CONDITIONS AT OHIO RIVER HIGH-LIFT DAMS; JANUARY 4-28, 1978

(Generated from Table 2 of Defendant's First Supplement to Proposed Findings of Fact, Filing Date February 29, 1984, pp. 8 - 10.)

Structure:	Date: Jan. 4	5	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Emsworth	100%	---	80	100	---	---	---	80	100	---	---	---	---	100	100	100	---	---	---	---
Dashields	100	---	---	---	---	---	---	---	---	---	---	---	---	---	80	90	---	---	100	100
Montgomery Island	100	---	80	90	---	---	---	---	90	80	---	---	---	---	100	100	---	---	100	---
New Cumberland	100	80	80	100	100	100	---	100	90	100	100	100	100	100	100	100	100	---	---	---
Pike Island	100	---	---	100	100	---	100	100	100	100	100	100	100	---	100	100	90	---	---	80
Hannibal	---	---	---	---	---	---	---	---	---	---	100	---	---	---	100	100	80	---	---	---
Willow Island	100	---	---	80	80	---	---	90	---	---	80	---	---	---	100	100	100	---	---	---
Belleville	---	---	---	100	80	100	---	---	100	100	---	100	100	100	100	100	100	---	100	100
Racine	---	---	---	100	80	80	---	80	100	100	100	100	100	100	100	100	80	---	---	---
Gallipolis[1]	---	---	---	---	100	---	---	90	100	100	---	---	---	100	100	90	---	---	---	---
Greenup	---	---	---	---	---	---	---	80	100	100	90	90	90	---	80	---	---	---	---	---
Meldahl	---	---	70[1]	50	50	50	90	80	100	100	100	100	100	100	90[3]	---	10	90	100	100
Markland	---	---	---	---	sho[2]	10	10	80	80	100	100	100	100	100	100[3]	100	100	100	100	100
McAlpine	---	---	---	---	---	---	---	---	---	---	---	---	---	100	100	---	---	---	---	100
Cannelton	---	---	---	---	---	---	---	---	---	---	---	---	---	---	90	90	---	---	---	---
Newburgh	---	---	---	---	---	---	---	---	---	---	---	---	90	---	90	90	---	---	---	---
Uniontown	---	---	---	---	---	---	---	---	---	---	---	---	90	90	80	---	---	---	---	---
Smithland	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

[1]The Proposed Finding conflicts with the lockmaster's log, which reflects 70% coverage.

[2]The Proposed Finding shows no ice at Markland, while the lockmaster's log shows shore ice.

[3]The Proposed Finding provides a number; the lockmaster's log has no ice code for the 23d.

The Table speaks for itself, by and large; it simply shows that all but the southernmost dam on the Ohio had some degree of ice problems in January, 1978. The chart does suggest that ice was worse at Markland than at other dams when viewed in terms of the number of continuous days at 100% coverage. We have carefully considered the data represented in the Table, and conclude that they are of little value in assessing either the severity of ice conditions at other structures or the potential impact of those conditions on events of concern today.

The Ice Committee Report is slightly more helpful in examining events at other dams, since it contains brief reports from Belleville and Racine Locks and Dams, the third and fourth projects upstream from Meldahl. We touch on these narratives only briefly, as they are of limited relevance in assessing what happened at Markland.

a. Belleville Locks and Dam.

At Belleville, located at mile 204.0 and the second structure in the Huntington District (Meldahl being the sixth and last), conditions were as follows:

> Ice was first reported at Belleville on 12 January in the form of light running ice. River flows were decreasing rapidly and total dam gate opening went from 50 to 29 feet on 13 January. Eight tows transited on the 12th without problems.
>
> The emergency gate bulkhead was placed into operation to pass ice in the auxiliary lock on 13 January. Light broken ice covered about 80% of the river surface upstream of the dam. Seventeen tows transited without problems from the 13th through the 14th of January. Density of the ice pack was increasing and ice continued to pass through the dam and auxiliary lock.
>
> On the 15th of January, river flow was moderate. Density and extent of ice upstream of the dam had decreased.

The ice pack extended about 4 miles upstream of the dam. Tows continued to transit without significant problems.

Ice stopped moving through the dam on 16 January due to decreased flow. The ice pack upstream of the dam increased on 16 and 17 January such that it extended 10 miles upstream. During this same period, twenty-two tows transited without significant problems. Ice was continuously passed through the auxiliary lock.

River flow increased slightly on 18 and 19 January. On the evening of the 18th, ice started moving through one gate on the dam. Broken ice was continuously passed through the auxiliary lock. The ice pack upstream of the dam because more dense, was stationary, and extended upstream about 3 miles. During this period, seven tows transited without significant difficulty or delay.

River flow increased slightly on 18 and 19 January. On the evening of the 18th, ice started moving through one gate on the dam. Broken ice was continuously passed through the auxiliary lock. The ice pack upstream of the dam became more dense, was stationary, and extended upstream about 3 miles. During this period, seven tows transited without significant difficulty or delay.

River flow remained fairly steady through 24 January with minor fluctuations. Thirty-three tows transited during the period of 20 to 24 January. Broken channel ice was continually passed through the auxiliary lock was coordinated wih lockages in the main lock to minimize adverse currents. The pack ice upstream of the dam had increased to about 9 miles. There was an accumulation of 22 inches of snow on the pack ice and ground.

Exhibit 179 at Exhibit 5, p. 1-1.

b. Racine Locks and Dam.

Racine Locks and Dam, located at mile 237.5, is 33.5 miles downstream from Belleville. Its entry in the Ice Report is as follows:

> Ice was first reported at Racine on 11 January 1978. There were no significant impacts resulting from ice until 20 January. During this period, river flows decreased allowing gate openings to go from a maximum of 94 feet on 11 January to openings in the teens. The ice continued to increase in density and to build up in the approaches and covered the entire river for a distance of approximately 8 miles above the project. During this period, ice was passed through the auxiliary lock and the dam. The number of lockages was slightly below normal.
>
> The first significant impact on navigation occurred on 20 January whe (sic) the upbound M/V A.V. CRISS with 11 empty standards was unable to break through the ice pack. She locked back downstream and waited for three downbound tows working as a team to clear a channel. After these downbound tows had locked through, the M/V A.V. CRISS made an upbound transit with only minor difficulty. This was the first evidence of developing ice problems.
>
> By 21 January, the ice had continued to pack and was layering. Areas around the lock were now covered with layered ice reaching 2 to 3 feet in thickness. Most locking vessels required assistance to penetrate the heavy ice. The ice pack would not move through the dam with the available gate opening and existing flows and only ice broken and pushed into the chambers by tows was passed.

Id. at p. 2-1. Of course, because these structures are upstream from Markland, river flows were lower; however, like Meldahl, personnel at both projects made continual efforts to pass ice, using the auxiliary on a continual basis and using whatever other means conditions permitted.

The report of activities at Belleville, however, illustrates another point worth noting — the overall long-term effect of passing ice when possible. On January 15th, the Belleville ice extended four miles upstream. On the 16th and 17th, it extended upstream 10 miles, as its passage had become difficult. However, ice-passage activities continued; by the 18th, the ice pack, though stationary, was reduced to three miles upstream. At no time was the ice extended more than the ten miles upstream reported on the 16th, although it did increase back to nine miles on the 24th.

12. The Whitlock Visit.

Writing for the Ice Report, Norbert Whitlock, then Chief of Operations for the Louisville District, stated:

> On 23 January, I visited the Markland site and boarded various towboats in trying to expedite and move traffic. It was observed that much of industry was not cooperating with each other. It wasn't until an industry representative and I contacted many of the boats by radio and got them organized and was able to wash the ice and help one another in and out of the lock chambers [sic]. Also, on 23 January, a Notice to Mariners was issued stating that we would only lock 70-foot wide tows because of the heavy ice buildup. Also, a decision was made to lock all downbound tows in order to get as many tows out of the ice as possible.

Exhibit 179 at Exhibit 6, p. 1. Mr. Whitlock's report also states that "on the 23rd, the tow that I was on was on ground in the middle of the river. It had ice built up approximately 20 feet deep under the barges which made navigation extremely slow and difficult." *Id.* at 2.

Mr. Whitlock testified on direct examination that given observed conditions and the extant weather forecast, he was satisified that conditions at Markland could only improve. He testified that it was his belief that if temperatures rose, a slow in-

crease in flows would permit ice passage through the dam, clearing the accumulation; if temperatures fell, the sticky ice would harden and knit together, and traffic would break a clean channel through.

On cross-examination, Mr. Whitlock's understanding of the ice situation at Markland and upstream from the project was seriously challenged. Although he testified on direct that he believed that there had been nothing but light floating ice upstream of Warsaw on the 23rd, his memorandum written to the Ice Committee in 1978 states, "[o]n 22 January, the ice conditions as reported were that there was bank-to-bank ice from three miles downstream of Rising Sun" down to the Markland project. Exhibit 179 at Exhibit 6, p. 2. Rising Sun, Indiana, is located at mile 506; according to Mr. Whitlock's Ice Report notation, then, ice was bank-to-bank from mile 509 (three miles downstream from Rising Sun) to Markland, located at mile 531.5 — 22.5 miles of ice.

Ice experts Lazier and Ashton were in agreement that the fact that Mr. Whitlock reported open water with 40-50% floating ice coverage at Warsaw on the 23rd was not incompatible with reports that ice was built up to mile 509 on the 22nd, for one reason. Vessels seeking to come down through Markland were being stalled by the deteriorating conditions at the project, and so they were tying off in Warsaw, the first town upstream from the project. Thus, there was substantial vessel traffic in the area at and upstream from Warsaw, traffic which, we find, broke up the ice in the area and caused the conditions reported by Mr. Whitlock after his brief voyage on the JACK BULLARD.

Captain Jerry Smith was master of the M/V BRIMSTONE in January, 1978. Captain Smith testified that he cleared Meldahl Locks, heading southbound, at 9:45 a.m. on the 23rd. At 7:00 p.m., the BRIMSTONE stopped in heavy ice at mile 497, nine miles upstream from Rising Sun. On the 24th, he was able to follow other boats through to mile 520½, midway between

Markland and Rising Sun; from that vantage point, Capt. Smith testified that he could see for one and one-half to two miles downstream, and that ice was bank-to-bank as far as he could see.

On balance, considering the evidence before us, we find as a fact that ice was built up to at least mile 509 — three miles downstream from Rising Sun — on January 22-23. First, we think that Mr. Whitlock's report, generated shortly after the events and in the context of the Ice Committee investigatory process, is more reliable than his recollections years later in the context of trial testimony. We also find Captain Smith's testimony generally corroborative on this point. We note our own perception that given the tremendous amount of ice which had come down the main stem, both from Meldahl, locally formed, and out of tributaries, it is incredible to think that ice would have built up only two or three miles from Markland, since virtually none was being passed through and literally miles of ice had been passed downstream through Meldahl. Given that up to ten miles of bank-to-bank ice had accumulated at projects which were diligently seeking to pass ice, *i.e.* Meldahl, Belleville, and Racine, it strains credulity to suppose that Markland had only a two-mile accumulation.

We note, in passing, that the precise extent of the ice upstream from Markland is unknown because no Corps personnel took any steps to conclusively determine the extent or nature of the ice in the Markland pool during this period, despite the fact that pool surveillance was required by the ice regulations, as well as, we find, simple prudence. As noted in the Huntington District report to the Ice Committee,

> [d]uring periods of ice, the Huntington District follows a routine of information gathering each day by talking to personnel at each structure. During these calls, the ice codes, submitted earlier, are reviewed and a verbal description of ice conditions is solicited. The daily weather at

each project is reviewed and added to the information. Next, the project's gate configurations and gages are obtained. *Reports and reconnaissance trips made by lock personnel are reviewed to provide a further assessment of the ice situation. Also, any reports obtained from passing vessels are integrated into the picture.* After having reviewed this information, a discussion of potential problem areas and what actions may be necessary should trouble develop is held to ensure both the field and the District Office are alert to the potential problems.

A second information gathering system utilized by the Huntington District is overflights of potential trouble areas and occasional general overflights of the entire river within the District.

Exhibit 179 at Exhibit 5, p. 3 (emphasis supplied).

No such surveillance, either by way of overflight or reconnaissance, occurred in the Markland pool. While Mr. Whitlock agreed that he had the authority to order an overflight, he declined to do so. He testified that, in his opinion, overflights are of minimal value because one cannot determine the contours of the ice; however, we can only conclude that they would be better than operating in an informational vacuum; the same is true of automobile surveillance, which Mr. Whitlock also decried.

What happened on the 23rd, then, was this. Mr. Whitlock visited Markland and organized some of the industry towboats to try to cut a passage through the ice down to the dam. He did not seek to organize the type of wheel wash operation which was proving successful at Meldahl, but he did receive cooperation from the industry vessels for clearing a path. However, these Corps efforts were not continued after the 23rd. Neither Mr. Whitlock nor Lockmaster Sheldon made attempts, save for the limited effort on the 23rd (of which Mr. Sheldon was not even aware) to obtain industry cooperation; Mr. Sheldon at no time made such an effort.

While at Markland, Mr. Whitlock made only limited attempts to gain information regarding the condition of the Markland pool. As we understand his testimony, he spoke with only one boat besides the one he rode on regarding conditions upstream, and his surveillance extended only to Warsaw, where a number of towboats were intentionally breaking up ice and circulating it through the river — and apparently based his conclusion as to the extent of the ice on that observation.

13. Tuesday, January 24 - Friday, January 27.

From the Ice Committee Report:

> By 24 January, temperatures had risen enough that moisture moving into the basin that day fell in the form of light rain. Intensity increased only slightly in the next 24 hours but there was no evidence of runoff or increased streamflow. It appeared that the snow pack was absorbing and holding the rainfall. Weather forecasts on the morning of 25 January indicated continuation of relatively light rain for another 12-18 hours and then a return to very cold conditions. While rainfall intensity was expected to increase slightly, total amounts expected were not considered alarming. Rainfall intensity increased a great deal more during the day than had been anticipated and, by late afternoon, the rain was being forecast to turn to heavy snow by about midnight and continue into the 26th.
>
> Forecast on the morning of 25 January had been based on belief that a low pressure system in the Gulf states, associated with a warm front to the south and southeast of the Ohio basin, would pass to the southeast of the basin and up the Atlantic coast without significant impact on the Ohio basin. Coming into the western and northwestern portions of the basin was a cold front that was expected to move eastward over the basin, bringing much colder air and shutting off moisture. Later in the day, the low pressure system unexpectedly joined th (sic) cold front, in-

tensified, and took a north-northeasterly path right across the Ohio basin. With record low barometric pressures, the storm passed through the Cincinnati area shortly after midnight with wind gusts reaching 50 mph. Gusts reached 80 mph by the time the storm exited the basin in the Cleveland area later in the day on the 26th.

Temperatures on the middle reaches of the Ohio plunged to around zero on the morning of 26 January and strong winds prevailed through much of the following day. Blizzard conditions paralyzed much of the area, but the most important factors relating to river ice had been the rainfall immediately preceding the developing cold air. In about 48 hours, rainfall intensity steadily increased from an insignificant drizzle to fairly heavy just before turning to snow. Rainfall averaged about 1½ inches over most of the southern tributaries. With outflow of storage reservoirs cut to minimums, runoff from remaining uncontrolled portions of these watersheds brought rapid stream rises. The collective effects of this outpouring into the Ohio main stem were rapid rises on the main stem, and operators of the navigation structures had no alternative but to simply pass through whatever water or ice came to them from upstream.

The river stage at Cincinnati rose from 29.6 feet on the morning of 25 January to 35.3 feet by the next morning and then to 46.6 feet by the morning of the 27th. Thereafter, the rise slowed and a crest of 53.9 feet was subsequently reached on the 30th. Ice movement, with periodic stoppage and accumulation, had been a significant problem since the 16th. By the 25th, several miles of the river upstream from Markland Dam had become so jammed with ice that navigation had essentially ceased. The rapid rise beginning on the 25th and the forcing of more ice into that jam then produced a nightmare for the next several days. It is difficult to know with certainty just

> when the massive ice jam began to become a gorge causing a damming effect. Best indications are that it was late morning on the 27th, when localized flooding was reported at Aurora, Indiana. In any event, force of the rapidly increasing riverflow soon broke the gorge in the afternoon and moved much of the ice down against Markland Dam.

In other words, weather conditions first moderated, and then significantly worsened. The early-morning forecast on the 23rd was for temperatures near 32°F, with "a good deal of melting and softenting (sic) of the snow on the ground . . . . It'll get messier tomorrow because rain will develop and continue tomorrow night [the 24th] — colder air will arrive on Wednesday — perhaps changing the rain to snow before it finally all ends Wednesday evening." The forecast, issued by Accuweather, referred to the "January thaw" as being in progress. Exhibit 316 at #8. By later in the day on the 23rd, however, the forecast was somewhat gloomier:

> After a rather stromy (sic) pattern the tranquil weather the past few days has come as a welcomed relief. Unfortunately that will come to a swift end. A frontal system now on the eastern slopes of the Rockies will approach early tom[orrow], sleet and snow will dev[elop] late in the day and it may changeover (sic) to just rain for awhile tom[orrow] nite. But were (sic) going to be on the border line between rain and snow and colder air will arrive Wed turning any precip over to all snow and some accum[ulation] is poss. The colder air that will cause the snow Wed will stick around into the Weekend.

Id. at #11.

The early-morning forecast on Tuesday, January 24th, was as follows:

> Despite the fact that early morning risers were able to see stars before dawn — today is going to be a cloudy day —

> and its (sic) going to become very messy. A mixture of precipitation will begin this morning and continue into tonight — most of it should not be especially heavy — but its going to make things very icy and treacherous today and tonight. Tomororow (sic) much colder air will begin to drop temperatures and we'll remain cold for the rest of the week.

Id. at #13. By the afternoon forecast, conditions were again predicted to worsen:

> The storm we've been wtaching (sic) for the past few days moved in[to] our area riet (sic: right) on schedule. The system is still centered way down on the Gulf coast and moving slowly northeastward. At the same time the storkm (sic) heads toward the eastcoast a cold air mass will be edging toward us. Before that cold air can get here we'll continue (sic) to have rain for awhile. As the cold air comes in the rain will grad[ually] . . . changeover to snow tonight and that snow will continue into tom poss accum a few inches. Frigidly cold air will then gain control of our weather Thurs into the beg[inning] of the weekend.

Id. at #15. By the forecast for 5:15 a.m. on Wednesday, January 25th, blizzard conditions were predicted:

> Snow [today] mixed with a little rain [illegible] snow heavy at times tonight and part of tomorrow. Falling temperatures and rising winds will result in extensive blowing and drifting snow tonight and tomorrow with blizzard conditions at times. Temperatures will fall through the 20s today to a low near 10 late tonight and remain in the teens tomorrow. Friday — blustery and cold with some sunshine — also some flurries. High 15. Snowfall from this storm is likely to reach 5 to 10 inches with much higher drifts by tomrorow (sic) evening.

Id. at #18. By later in the morning of the 25th, the storm was predicted as follows:

> Start getting prepared — We are about ready to experience quite a winter storm. This morning will be rather tranquil and you'll be able to get outside to do what you have too — but snow will begin to fall today — the wind will begin to increase tonight and before it all dies down some Friday we are going to have quite a mess. It looks like at least 4 or 6 inches of snow — and winds gusting over 50mph (sic) tomrorow (sic) will cause severe blowing and drifting. In addition temperatures will fall sharply tonight reaching the teens or lower and staying there thru (sic) Friday . . . .
>
> A low pressure area now in northern Mississippi is going to move northeastward today and become a super storm by this time tomorrow — it means some very nasty weather for us with snow, blowing snow, sharply falling temperatures — blizzard conditions and very strong winds — the snow will begin this morning — the height of the storm in terms of wind and blwoing (sic) snow will come late tonight and tomrorow (sic) — how much snow are we expecting — well it will be difficult to tell because of the blowing and drifting — but 6 or 8 inches seems like a very good bet — and greater amounts — up to 10 or even 12 inches possible — with much higher drifts by tomorrow night.

Id. at 19. By noon on the 25th, the forecast was that:

> A very powerful storm perhaps the strongest of the Winter will move up through the Great Lakes region during the next 36 hours — and our weather will undergo a frightful change to colder weather. As the storm begins to get organized we can expect periods of snow and sleet here this afternoon. Gale force winds will develop about the storm center tonight and tomorrow bringing frigid artic air into our region and that combined with snow and blowing snow will make it look like a blizzard at times. Blustery cold weather will continue (sic) here on Friday then things will settle down a little bit during the weekend.

Id. at #20.

Consideration of the forecasts in the context of the Ice Report excerpt demonstrates that the storm did in fact come as something of a surprise to the Ohio Valley. The storm was of blizzard intensity, and was accompanied by record low barometric pressures. The Government argues that the storm was wholly unpredictable and a freak of nature; we find that this position somewhat overstates the situation. Accuweather's Sobel testified that his practice is to review forecasting information for the 48 hours subsequent to the time at which a forecast is being generated, and to hold off on predicting major weather changes until they are confirmed over the following twenty-four hours. Thus, he testified, computer-generated charts issued by the National Weather Service permitted tentative forecasting of the storm as early as the morning of the 24th.

a. Activities at Markland.

The midnight-to-noon entry for Markland on the 24th indicates that ice was being washed through the main lock; that 35,200 cfs of flow was being diverted to the hydroelectric plant; and that the propeller unit from the pusher boat was removed and sent to the Corps' Louisville Repair Station. Ice conditions were coded as "10-P-5-L-X" — 100% coverage, stopped, 5" thick, layered, continuing out of sight from the dam.

Diversion to the hydroelectric plant at or near maximum flows continued throughout the next several days. On the 25th, lockage activities were halted at 11:00 a.m. due to heavy ice conditions. Ice was being passed through the main chamber as long as lockages continued; the two activities were interdependent, in that lockage of ice through the main chamber is contingent upon the ability of tows to navigate down into the lock approach area, pushing as much ice as possible ahead of the tow

into the chamber. Thus, once lockage becames (sic) impractical, no further ice passage through the chamber could occur. The log entry for the afternoon of the 25th thus indicates no ice passage through the main chamber, but some passage of ice through dam gates 4 and 5.

That notation — "[w]ashing ice thru Gates 4 and Gate #5 on dam" (Exhibit 121 at January 25, 1978) — is of interest for two reasons. First, it indicates that, contrary to the overall position of the Corps regarding the capability of Markland to use overflow ice passage configurations at times of low flow (the dam was running only 13' of gate opening at the time), such passage was in fact one of the options available to Markland personnel.

In fairness to the Government, we note that Assistant Markland Lockmaster Ryle testified that "there's a lot of time[s] that we wash ice but we don't necesarily put it on paper . . . . A lot of time[s] during the day we might be washing ice out there but we don't put it on record." Tr. I at 511-12. However, we have difficulty crediting that assertion in light of the absence of any mention of overflow ice passage activities in the log prior to the 25th, and in light of Lockmaster Shelton's testimony that any such activities *would* have been noted in the lock logs (Tr. I at 821). We therefore find that no significant overflow passage efforts occurred prior to the afternoon of January 25th.

We also note, in this regard, that the position of the Government has consistently been that, once ice has built up three miles or more from a structure such as a dam, passage of ice through the structure is of no significance in terms of dealing with ice accumulated further upstream, as that ice gains lateral structural support from the river banks themselves and is no longer dependent upon the dam for support. Thus, attempts at ice passage at Markland only when lockage had ground to a complete halt was quite simply too little, too late. While we find, as developed below, certain factual inconsistencies with the Government's

position in this regard, we do observe that there is no question but that these last-minute ice passage attempts accomplished little, if anything, in terms of clearing ice from the Ohio River upstream from the dam.

On the 26th, Markland locked no vessels, but continued efforts to wash ice through the dam. At this point, river flows started increasing; dam gate openings had been 13' total on the 25th, but were up to 45' by 6:00 a.m. on the 26th. We are at a loss to explain the midnight gate opening/hydro plant readings, as they indicate 34' of gate opening with only 12,400 cfs diversion, while 34,000 cfs were diverted to the plant at 6:00 a.m. At any rate, we observe that there is no testimony to the effect that diversion to the power plant was reduced during the night of the 25th-26th to make flows available for ice passage. We question, but do not discredit, the entry. At 6:00 a.m. on the 26th, the ice code as reported as "10-J-X-T-[illegible]-X" — 100% coverage, indicating little or no success with ice-passage efforts; jammed; thickness unknown; extent upstream unknown.

By noon on the 26th, the dam was running 71' of gate opening; no figure is given for hydro plant diversion.

b. Flow Conditions.

We digress momentarily to examine river flow conditions for the week now under consideration, and then catch up with activities at Meldahl before examining the events of January 27th.

From Exhibit 219, Mean Daily Flow statistics and forecasts for a number of points along the river and including all high-lift dams, we glean the following observed river flows at various locations for the days from the 23rd on (in 1,000 cfs):

	Jan. 23	24	25	26	27
Meldahl	79.4	68.2	99.7	226.0	303.0
Cincinnati	87.5	76.1	115.6	265.6	356.1
Markland	90.8	79.5	98.2	212.7	322.8
Louisville (McAlpine Upper)	109.5	95.0	122.4	499.6	332.1

These figures[4] demonstrate that, from January 24th to the 27th, Markland Dam was receiving less water than Meldahl was passing. This fact is difficult to explain, all other factors being equal, as there usual course of things is, as examination of Exhibit 219 demonstrates, for flow at downstream locations to be greater than flow at upstream locations. We find that what had occurred was, for reasons more fully developed in our discussion of the parties' view on the issue of causation, *infra,* that ice had begun to form a dam in the river upstream from Markland which was holding back water coming downstream, resulting in lower flows at Markland despite the fact that tributaries and natural runoff were resulting in the addition of water to the main stem during these days.

c. Conditions at Meldahl.

The Meldahl logs (Exhibit 129) reveal the following regarding the 23rd and subsequent days. On the 23rd, 24th, and the morning of the 25th, Meldahl had approximately 30' of gate open-

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[4] We note that the parties have stipulated that during the period from January 17 through January 24, flows at Markland were "fairly constant . . . with the lowest flow being 92,000 cubic feet per second . . . ." Doc. 219 at ¶ 100. We do not know the source of the information provided in the stipulation, but, given our understanding that the first column of each page of Exhibit 219 constitute observed flows for the date of issue, we prefer the Exhibit over the stipulation.

ings. It as at all times concentrated on two gates; Meldahl had managed to maintain its ice pack at 90% coverage, and ice was running through the dam and the auxiliary chamber. We note, again, that through the entire period in question, Meldahl was constantly passing ice through the dam, organizing private tows to break up and move ice through the dam and through the lock chambers, and using the auxiliary chamber to pass ice. Shortly after noon on the 25th, Meldahl started increasing its gate openings in response to increases in river flows. Thus, at 1:30 p.m., gates were open 41'; at 4:20, 48'; by evening (the time is illegible) 65'. The entry for the 25th includes the notation "Blizzard — started 9:00 p.m."

On the 26th, Meldahl's gate openings continued to increase, going from 65' at midnight to 151' at 11:30 a.m. to 272' at 10:30 p.m. At that point, lockage had ceased due to inclement weather. After midnight on the 26th, flows continued increasing rapidly, and at 2:40 a.m. on the 27th, Meldahl went "all out," meaning that all 15 of its gates were raised the maximum of 35' of their sills. At that point, of course, the dam was doing very little to impede the natural flow of the river.

14. The Gorge.

We excerpt from Norbert Whitlock's report to the Ice Committee:

> On 26 January, up in the night, after monitoring the flow and what was happening at Meldahl, Gallipolis, and up on the river, the Coast Guard was advised to issue a Notice [to Mariners] that a very substantial ice jam was reported [by towboats] at mile 515, in the vicinity of Hamilton Light. We were advised by the towboat, the M/V T.M. NORSWORTHY, at approximately 1538 hours on the 26th, that she was three miles above, 6 empty barges were broken loose in the ice, and she was with two barges against the bank.

> On 27 January, early in the morning, after receiving the gages, we observed that Gallipolis, Greenup, and Meldahl were all out; and Meldahl was only running 101 feet, making Markland some 120 feet behind. That morning we had heard that the T.M. NORSWORTHY and the BRIMSTONE's tow[s] were split up, and that the jam at Mile 515 had moved at 8:00 AM. At approximately 0800 hours, Markland, was running 16 feet on Gates 2 through 8. At 9:05, the jam was reported to have stopped moving.

We interrupt here to note that we do not understand Mr. Whitlock's observation that "Markland [was] some 120 feet behind" Meldahl, as Meldahl was, once it was all out, running 420' of gate openings (35' on 12 gates). However, the record does not indicate a basis for discrediting that assertion, which may have been made on the basis of information pertinent to actual flows observed at Meldahl. That is, the fact that the dam was all out does not necessarily mean, as we understand the matter, that all of the available space was actually consumed by the river.

Returning to the narrative:

> On 27 January, at . . . 12:16 PM, I advised the Coast Guard that an 18.4-foot rise at Greenup Locks, Mile 341.1, and an 11.3-foot rise at Cincinnati, Mile 470.3, had occurred in the last 24 hours. The ice gorge reported at Mile 515 is subject to breakup due to rapidly rising water levels.
>
> Throughout the night of the 26th and during the day of the 27th, I continued to investigate what boats were above Markland and contacted all companies to determine, by barge number, what was in each tow. At 9:37 on the 27th, I talked to Houston Barge Line concerning its T.M. NORSWORTHY which was at Mile 516.5. At 9:48, I talked to Walker Towing Company (Mr. Bob Day) concerning the AGNES MAE. The AGNES MAE was tied off to the floating mooring facilities at 515+. At 1000 hours on the

27th, I was advised by Markland that the PEACE with 12 barges was still with her tow. At 1100 hours, I was advised by Markland that the H.J. THATCHER, of R&W Marine, had just broke loose and was coming down on the dam. Mr. Sheldon was advised to put 3 to 4 people on the dam to stand watch and operate gates and attempt to pass ice as it came. It was also reported at that time that there was a 6-foot wall of ice, approximately 200 feet above the guardwall. At noontime, we started getting reports that there was evacuation taking place at Rising Sun and that there was water in the streets at Aurora, Indiana.

* * *

On 27 January, at 4:17 p.m., the ice gorge broke loose. Four barges were coming downriver. These were four barges from the AGNES MAE's tow. Four empties, two loads, one grain and one #6, were at Big Bone Island. According to the AGNES MAE, the gorge was 3 miles long and very heavy. at (sic) 4:21 PM, the M/V PEACE's tow broke loose. The pilot radioed to Markland that it almost knocked him out of the pilothouse. The heavy ice above the gorge was at Baxter's Light. At 4:20, ice was going through the dam. Additionally, the ice was also coming up on the guardwall, rolling up on the guardwall. At 1700 hours, Markland advised that it had four men on the dam and that they were attempting to manipulate the gates to pass ice. Aurora Terminal advised that water was in the streets. I talked to Lee Gregg of the Coast Guard at 1712 hours. Lee advised that an individual had told him that he could see the ice coming. It was bank-to-bank and moving at about 4 to 5 miles an hour. At 1714 hours, more barges had broken loose, the ice was passing through the dam, and the water was still rising. Flood stage at Cincinnati is 52 feet, and at noon it was 53 feet. The National Guard was evacuating some areas in Ohio County.

Exhibit 179 at Exhibit 6, ¶¶ q-t, x. We are not devoting time to the events attendant to the breakup and progress of the ice gorge down to Markland, as our primary concern in this case is with what caused the gorge. We do excerpt, below, sections of petitioners' proposed findings, which we adopt as accurate, pertaining to the progress of the M/V AGNES MAE, but first, make the following findings.

1. An ice gorge, consisting of a bank-to-bank "dam" of ice extending an unknown depth beneath the surface of the river, formed in the immediate vicinity of Big Bone Island, a small, natural island which was, at the time, located at mile 515 in the main stem, 16.5 miles upstream from Markland Locks and Dam.

2. While the weather events during the periods January 25-27, 1978 were in many ways extreme, *i.e.*, blizzard conditions occurred, the increase in flows which occurred was of a magnitude which occurred approximately every two years; the rise did not occur especially quickly (Mitchell testimony).

3. During the 24th, 25th, and 26th, Meldahl was passing more water than was being passed through Markland, indicating that the gorge was having the effect of retaining some water (Exhibit 219).

4. As the flow increased, the ice-packing phenomenon discussed *supra* led to increased compacting and congealing of the gorge, and substantially contributed to its density and mass.

5. As the gorge increased, the amount of water which it impounded upstream increased commensurately.

6. As water was impounded, a "differential head" — meaning that the water level upstream was higher than the water level downstream of the gorge — began to occur.

7. The gorge broke loose as the result of pressure exerted by the higher water — the differential head — upstream, which finally broke through, pushing the gorged ice along with it.

We discuss later in this opinion our conclusion of law and fact that the gorge was caused by negligent operation of Markland Dam. We think the carnage wrought by the movement of the gorge, a subject which could be considered at length, is adequately described by Mr. Whitlock's memorandum, to which we add only that what occurred was probably the greatest single disaster to hit the Ohio River in modern times. Barges, towboats and docks were swept onto or through Markland Dam; barges and towboats were sunk; Big Bone Island was simply shaved off, and does not now exist. Cleanup operations took weeks, and these events have earned a permanent place in Ohio River lore.

We now insert, in edited fashion, a section from petitioners' proposed findings entitled "The Voyage of the AGNES MAE" (doc. 244 at 68-75):

"THE VOYAGE OF THE AGNES MAE"

"In January of 1978, petitioner Walker Towing Corporation owned and operated the M/V AGNES MAE, a steel-hulled river towboat 140 feet long and 38 feet wide. The AGNES MAE was powered by two diesel engines, each with a rated horsepower of 2650.

"On January 17, 1978, the M/V AGNES MAE manned by a crew of eleven and with a tow of five empty barges commenced her voyage south on the Ohio River toward Markland Locks and Dam. On January 18, she arrived at Mile 318 on the Ohio River, dropped three barges and took on four. She then departed southbound at 2:00 p.m. on January 18, and locked through Greenup Lock and Dam and traveled downriver to Mile 347. At 8:45 p.m., the AGNES MAE took on two more empty barges, and departed from Mile 354 at 1:30 a.m. on January 19. Thereafter, it traveled downstream and arrived at Meldahl Locks and Dam at 7:40 a.m. on January 19.

"The AGNES MAE encountered heavy ice which impeded but did not stop its progress, as well as the progress of other vessels navigating southbound above Meldahl Lock and Dam.

"However, in spite of the heavy ice above Meldahl, personnel at the lock continued locking boats through the lock. As noted elsewhere in these proposed Findings of Fact, in stark contrast to the actions of lock personnel at Markland, the Lockmaster at Meldahl, Raymond Dunaway, organized industry towboats to assist lock personnel in washing ice through the dam and utilized the auxiliary lock and tainter gates to pass ice from the upstream side of the dam to the downstream side of the dam. The AGNES MAE, along with vessels operated by other companies, assisted in these efforts. The AGNES MAE remained above Meldahl from January 19 through the morning of January 22, and finally locked through Meldahl at 9:40 a.m. on January 22. She then proceeded downstream to Mile 441.5 where she dropped three empty barges.

"On the trip downriver from Meldahl to Cincinnati, Ohio, the ice in the river did not hinder the navigation of the AGNES MAE or other vessels which had locked south through Meldahl. The ice in the river south of Meldahl to Cincinnati was floating, moving with the current and did not cover more than 50 percent of the river's surface.

"The AGNES MAE arrived at Southern Harbor, Mile 473 of the Ohio River, at 2:30 p.m. From that time until 5:30 p.m. on January 23, she took in tow 10 loaded barges. When she departed from Southern Harbor in Cincinnati, the AGNES MAE had 15 barges in tow, arranged three wide and five long.

"The AGNES MAE departed from Southern Harbor at 5:30 p.m. on January 23, 1978. Prior to departing south, the AGNES MAE had not received any warning or notification from any government agency about the worsening ice conditions in the Markland pool nor was it advised not to proceed further south in the Markland pool. Nor was it advised that

there was any restriction on locking tows at Markland Locks and Dam. Indeed, no warning about the ice gorge which developed at Mile 515 due to the build-up of ice upstream from Markland Lock and Dam was given until late on the afternoon of January 26, when the Coast Guard broadcast that an ice gorge existed at Mile 515.

"The AGNES MAE did not encounter heavy ice after departing Cincinnati until it reached Mile 499 on the Ohio River. At that point, the river was packed with ice bank to bank which hindered further progress downstream. Other vessels also encountered the heavy ice including the M/V T.M. NORSWORTHY, a 4200 horsepower vessel operated by Houston Barge Lines, which had a tow of eight barges, the M/V BRIMSTONE, a 4000 horsepower vessel, operated by Houston Barge Line which had a tow of four barges, and the M/V NORTHERN, a 5000 horsepower vessel operated by Dravo Mechling, with a tow of 16 barges.

"As is customary, the vessels moving south toward Markland assisted each other in navigating through the ice. The AGNES MAE and NORTHERN agreed to assist each other downstream through the ice to mooring locations closer to Markland Locks so that each boat could secure a locking turn and lock south out of the Markland pool.

"Thereafter, on January 24, the NORTHERN and the AGNES MAE, working together, moved the AGNES MAE's tow to Mile 514. At that point, the AGNES MAE's tow was tied off at the Hilltop concrete dock at Mile 514 on the right descending bank of the Ohio River. The tow was tied off by approximately 9:00 p.m.

"On the morning of January 25, Captain Spinx of the AGNES MAE, contacted Markland Lock to establish a locking turn and was advised by lock personnel that the AGNES MAE would be number 10 locking through southbound. Lock personnel did not advise Spinx that Markland would cease to lock

downbound tows on January 25. Nor did lock personnel provide any information regarding the ice conditions upstream from Markland or mention the formation of an ice gorge at Mile 515. Later, during the day of January 25, a broadcast was issued which restricted lockages at Markland to upstream lockages only and vessels above Markland, were advised to find safe moorings above Big Sugar Creek at Mile 523 and remain at such locations until advised by the Lock Master at Markland to proceed downriver toward the lock. The AGNES MAE at all times before the gorge broke was above Big Sugar Creek. Unfortunately for the AGNES MAE and other navigators above Markland, the January 25 broadcasts concerning mooring above Sugar Creek placed them directly in the path of the ice gorge. Thus, the warning was not only too late, but it was misleading since it directed mariners to moor below an ice gorge which lock personnel either knew or should have known existed.

"On the morning of January 25, the AGNES MAE navigated upstream to Mile 502 where the NORTHERN had left its tow in the ice and with the AGNES MAE proceeding ahead of the NORTHERN and its tow to break a path, the two vessels pushed downstream through the ice to Mile 521 where the NORTHERN's tow was tied off on the left descending bank. The NORTHERN's tow was tied off with three comeback lines around trees, a wire cable and an LST line. The trees to which the lines and the wire that the NORTHERN secured its tow with were approximately one to two feet in diameter. The river was completely covered with ice from Mile 499 to Mile 521 where the NORTHERN's tow was moored.

"The M/V BRIMSTONE followed the path broken through the ice by the AGNES MAE and the NORTHERN and moored its tows next to the NORTHERN's tow at Mile 521. Both the NORTHERN and the BRIMSTONE remained at Mile 521 until the gorge broke on January 27.

"After assisting the NORTHERN to Mile 521 on January 25, the AGNES MAE returned to its tow at Mile 514. The AGNES

MAE and her tow remained tied off at the Hilltop concrete dock until 9:30 a.m. on January 26. At that time, the ice shifted and the AGNES MAE's tow was broken loose from the Hilltop dock. The six part line securing the AGNES MAE's tow to the Hilltop dock did not break; rather, the force created by the ice moving was so great that the line pulled the mooring ring off the cell. The AGNES MAE's tow moved downstream with the ice to Mile 516.5. At that point, she secured her tow to the Federal mooring buoys above Sugar Creek on the right descending bank of the river in accordance with the Corps' directive. The Federal mooring buoys were located below a point or bend in the river. The credible evidence clearly indicates that mooring the tow between a point was a safe and prudent decision and in accordance with good seamanship in view of the prevailing river conditions.

"The T.M. NORSWORTHY and its tow which were located at Mile 510 of the Ohio River also were forced downstream by the movement of the ice on January 26, approximately two miles. The rigging securing the two lead barges into the NORSWORTHY's tow broke during this movement and these two barges were moored to a tree on the right descending bank with a cable. The remaining barges were stuck in the ice and could not be moved.

"During the evening of January 26, the ice shifted again and broke the tow of the AGNES MAE away from the Federal mooring buoys at Mile 516.5. The AGNES MAE attempted to back the barges upriver and resecure them to the Federal mooring buoys, but because of the heavy ice was unable to do so. On the morning of January 27, the captain of the AGNES MAE, Harry Milam, directed that the tow be broken into two units, one unit of six barges and a second unit of nine barges. After this was accomplished, the group of nine barges was pulled back upstream to the mooring buoys where they were secured with two one-inch wires tied with a total of four leads.

"On the morning of the 27, the AGNES MAE remained tied off at the Federal mooring buoys. The M/V PEACE, a 5200 horsepower vessel, operated by Dravo Mechling, was moored across the river slightly upstream from the Federal mooring buoys at Mile 516. The PEACE's tow was tied off with two, one and one-half inch lines and two 600 foot two inch lines to trees on the left descending bank. The T.M. NORSWORTHY was tied off alongside the PEACE's tow. On the morning of January 27, the captain of the PEACE, David Combs, looking upstream observed ice 12 to 14 feet high in the Hamilton Light area at Mile 514.8.

"By January 27, bank to bank ice covered the river from approximately Mile 500 to Markland Lock and Dam. Captain Himes aboard the NORTHERN stated that he could see to the mouth of Sugar Creek at Mile 524 and upriver from the location where the NORTHERN's tow was moored and that the entire river was covered bank to bank with ice. Captain Combs aboard the PEACE, and Captain Milam aboard the AGNES MAE testified that ice in the area of Big Bone Island, upriver and downriver from their locations, was bank to bank. The captain of the M/V TEXAS, which was tied off at Mile 524, stated that ice was bank to bank upstream and downstream from 524. Lock personnel at Markland indicated that ice extended upstream from Markland as far as they could see from the dam.

"At 4:15 p.m. on January 27, the gorge broke. At the time the PEACE and the T.M. NORSWORTHY were faced up to the downstream end of the PEACE's tow and came full ahead with both boats to hold the tow in place. In spite of their effort of pushing full ahead with the combined 9200 horsepower of both boats, the ice, which was in chunks nine to ten feet tall and running bank to bank, forced the two vessels and the PEACE's tow downstream. Just as the tow was beginning to stop through the combined effort of both vessels pushing ahead with full power, deck fittings on the barges and two began breaking.

"The NORTHERN's tow was broken away from the bank, pulling one of the trees to which it was tied out of the bank. The two barges which the T.M. NORSWORTHY had secured to the right descending bank with cable uprooted the tree to which they were tied when the ice forced them downstream. Although the AGNES MAE attempted to hold its tow at the mooring buoys by pushing against it from the downstream side, the tow broke loose and the barges went downstream. The credible evidence indicates that when the gorge broke, it moved at a speed of four to five miles an hour, the ice was in large chunks or pieces which were continuously tumbling and churning in the river."

The United States argues that the crew of the AGNES MAE was negligent in their decisions where and how to moor the vessel and her tows prior to the breakup of the gorge. We do not go through all of the steps taken by the vessel crew in preparing for ice movement, to the extent they were or should have been aware of the possibility therefor; nor do we proceed on a cable-by-cable, rope-by-rope examination of the vessel's moorings, as the Government would have us do. We have reviewed the documents and the testimony of petitioner's witness, Captain Edgar Allan Poe. We recognize that one of the law firms representing petitioners has used Captain Poe as an expert witness in other cases, and we surmise that this is so because he is, in fact, a very persuasive witness. We find as a matter of fact that the master and crew of the AGNES MAE proceeded in prudent, seamanlike fashion, and we attribute no negligence to their actions.

16. The Downstream Claim.

We now turn to consideration of events leading to the losses sustained by petitioner B-R River Services, Inc. B-R, now defunct, operated a fleeting service at river mile 600.8, just upriver from Louisville, Kentucky. A fleeting service is a storage facility for barges waiting transfer to the appropriate

towboats, much like a railroad switching yard. The service owned and operated the M/V BILL EDWARDS, a 900-horsepower harbor boat used to move barges between various berthing spots in the fleet and between the fleet and tows in the river.

The gist of B-R's claim is that a "shock wave" or "surge" which passed through Markland on the afternoon of Friday, January 27, rolled downriver and into the Louisville area on the morning of Saturday, January 28, tearing the B-R fleet loose from its moorings.

a. Clean Coal Terminals.

There is no question but that Markland Dam did not pose a major obstacle to the downstream progress of the ice and water which came down on the dam after the gorge broke on Friday afternoon. Petitioners called Ben Butler, a retired Major General, U.S. Army and Army Reserves, as a witness. In 1978, General Butler was operating a coal loading terminal some three miles downstream from Markland. He described in some detail the events at Clean Coal Terminals as they unfolded after the gorge broke, and also submitted a memorandum generated immediately after the events in question. We found General Butler extremely credible, and note that he has no connection with or interest in this litigation.

Much of the General's testimony is of primarily anecdotal value, but demonstrates the intensity of the phenomena involved; for example, he testified that, while picking up the wife of one of his employees just upstream from Markland, he saw a barge "picked up in the ice; it was heaving the barge out of the ice I would say about 10 feet or more." Tr. I at 549. As to the ice,

> I never seen anything like it, and the way it was doing it was pushing on the banks, of course, the weight of the water. In fact, this thing was estimated to be 30 feet (sic) long, which figured out with the speed of the river and the

> time it took to pass us. And it was pushing the ice to the banks and it would go and come against the banks with such force it would pile in the air and fall back in the river with a great grinding and crashing noise. It was a very frightening situation . . . . [I]t looked to me it was going from 10 to 20 feet [up in the air]. I could have been excited, but it was getting pretty high . . . Great massive chunks of ice, massive chunks. Some of them as big as this [court] room; just pushed in the air and flopped over.

Tr. I at 550-51. As to events at Clean Coal Terminals after he returned from his rescue mission, General Butler noted that "the dam really saved us a lot of grief and it had broke up some of these enormous chunks. It wasn't nearly as big when it reached our area, it didn't appear to me. But it was still a surge, heavy surge of ice and a rapid increase in the level of the water." *Id.* at 554.

General Butler made notations of the water level at his facility, and we reproduce the levels testified to in linear form:

12:30 p.m.	443 ′ above sea level
2:30	441 ′
5:00	447 ′
6:00	449 ′
6:30	449.6 ′
7:00	450 ′
7:30	450.6 ′
8:00	451 ′
8:30	451.2 ′

Id. at 556-57; *see also* Exhibit 241.

General Butler also testified that bank-to-bank ice ran by Clean Coal from 5:30 p.m. until 10:00 p.m. Regarding the effect of the flowing ice on barges fleeted at Clean Coal, he testified that several barges, fleeted with their rake ends

upstream, were partially broken from their moorings and swept around, either streamward or shoreward; one barge was pushed into the bank some ten feet, and four others broke loose altogether and started downstream. He testified that three-quarter inch steel cables, "which are the normal cables that tie barges together . . . in fleeting," "snap[ped] just like strings" from "[t]he surges of the ice. They would rock up and down, and the ice got against them, got under them, and just finally pushed them away and broke them." Tr. I at 560-61. However, General Butler also testified that, at the time the ice hit Clean Coal, he had excess barges in his fleet, a fact which may or may not have contributed to the number of breakaways which occurred.

b. The Louisville Harbor.

Leaving Clean Coal Terminals, we progress downstream to the area upstream of Louisville were B-R was located. We accept petitioner's account:

> [O]n Saturday morning, January 28, 1978, the 'shock wave,' 'transient wave,' or 'surge' and the major portion of the ice floes from the ice gorge above Markland Dam hit the Louisville harbor. Ice was flowing in the river from shore to shore. One deckhand noticed two ice floes which were two to three feet high and 'as long as a football field.' The river current was variously estimated at 5-10 mph, which as an unusually swift current for the Ohio River.
>
> At approximately 11:25 a.m. on the morning of the 25th [sic: 28th], the M/V Bill Edwards reportedly (sic) on its marine radio that it was having difficulty keeping its fleet under control along the bank and warned that it was about to 'top around.' The fleet was divided into upper and lower sections, with nine loaded barges, a wharf barge and a crane barge in the upper fleet and thirteen empty barges, one loaded barge and two partially looked [sic: loaded] barges in the lower fleet.

> At approximately 11:35 a.m. Saturday morning, January 28, the barge breakaway occurred at the B-R fleet. The first lines to part were the lines between the shore and the wharf and crane barges, caused by the ice pressure, which caused the entire upper fleet to 'top out,' or shift out into the river at an angle.
>
> The topping around of the upper fleet put pressure on the crane barge which was below the wharf barge, which in turn put pressure on the work barge. When the fleet started topping around, James Bennett, the fleet manager, who was on board the M/V Bill Edwards, moved the vessel down below and underneath the work barge, to try and get it out of the upper fleet, which resulted in pressure on the crane barge and the work barge, also resulted in pressure on the M/V Bill Edwards which was moored below the work barge, causing it to lean and almost topple over. The crew of the vessel had to abandon it temporarily.

Doc. 244 at 78-79 (citations omitted). And so it went, barges breaking loose and knocking other barges loose, until the B-R fleet was essentially in a shambles. By the time things settled down, more than two dozen barges had broken loose, including some knocked out of another fleet by the B-R breakaways; four barges and a small workboat sank; and damages totalling nearly $2.3 million were sustained as a result of this aspect of the casualty.

We have no question that, as demonstrated by, *e.g.*, Exhibits 296 and 299, as well as testimony from Mr. Lazier, Dr. Kennedy, and Dr. Hans Kivisild, there was indeed a "surge" of water which was the result of the breakup of the gorge at Big Bone Island and its passage through Markland Dam. This only stands to reason; there was a 10-foot differential head on the gorge when it broke, and that tremendous volume of water was essentially released at the same time. However, we also credit testimony from Government experts to the effect that as such a

surge progresses downstream, it flattens out and becomes less and less significant, somewhat like the ripples from a stone tossed in a still pool. We note that there were no other fleet or barge breakaways in the Louisville area save that at the B-R site. We therefore turn to consideration of the extent to which the B-R breakaway may be traced to the actions of B-R personnel themselves.

James Dowell, a pilot on the M/V JACK BULLARD, testified that the B-R fleet was extended too far out into the channel for safety. The B-R site is located in little more than a slight widening of the river, and barges were six abreast out into the river at the upstream end. The fleet was arranged such that *loaded* barges were upstream, while *empty* barges were downstream. In addition, although this point is disputed, we find the rake ends of the barges were pointed downstream, so that when the ice hit, it came into contact with the box ends of loaded barges. It was thus impossible for the ice to go under the barges, and the alternative occurred — the barges were ripped loose. We think that prudence required that the fleeting service take steps to thin its fleet to no more than three barges wide, and that steps should have been taken to place shear barges — barges angled at about 45° from the fleet at its upper end — to deflect the ice as much as possible in order to avoid breakaway. The result of these inactions and misplacements was, as the Government observes, that not only were the heaviest barges upstream, but they were unprotected by shear barges, and had their box ends upstream.

We conclude, applying the pure comparative negligence rule applicable in admiralty cases, that the fleeting service met its burden of proving that the events at Markland Dam were partially responsible for its losses, but that the Government met its burden of demonstrating that the fleeting service was itself equally responsible, through faulty preparation in the face of worsening river conditions, for its losses.

V. CONCLUSIONS OF LAW

A number of legal issues are presented for resolution. The United States raises as defense issues of discretionary function and *force majeur,* and also denies both that it was negligent and that any negligence which might have occurred was causally related to the damages sustained by petitioners. We indicated at the outset our conclusion that petitioners prevail in this action and we address the issues of law in reverse order, first considering the matters raised by way of defense.

A. The Discretionary Function Exception

The discretionary function exception to the Federal Tort Claims Act, 28 U.S.C. § 2680(a) (1974), provides an exception to the Act's general provision for government liability "in the same manner and to the same extent as a private individual in like circumstances." 28 U.S.C. § 2674 (1946). The exception is that the Act

> shall not apply too (sic) —
>
> (a) Any claim . . . based upon the excercise or performance or the failure to exercise or perform a discretionary function or duty on the part of a federal agency or an employee of the Government, whether or not the discretion involved be abused.

In *In re Ohio River Disaster Litigation,* 579 F. Supp. 1273 (S.D. Ohio 1983), we considered at some length, on the Government's motion for summary judgment, issues pertinent to the application of the discretionary function exception to this case. We first concluded, following cases from several Circuits, that the exception should be read into the Suits in Admiralty Act. *Id.* at 1277-79. We next concluded that, under the leading cases of *Dalehite v. United States,* 346 U.S. 15 (1953) and *Indian Towing Co., Inc. v. United States,* 350 U.S. 61 (1955), two aspects of the Government's actions initially challenged in this case were exempt from suit. These were the decision where to place

Markland Locks and Dam, and the decision not to include in the project an ice and drift chute. *Id.* at 1281-82. These decisions had been challenged by petitioners as having been negligently made.

We next determined that the United States was not immune from suit in this case for the decision to incapacitate, either functionally or physically, the submergible tainter gates, and for formulation by the Corps of Engineers of "ice plans" and "operating plans" for the structure. For two reasons, we review those determinations anew. The first, of course, if that the matter is now submitted on the merits, while the prior determination as made upon application of the summary judgment standard. The second is that our previous decision is appropriately reexamined under the terms of a recent Supreme Court decision, *United States v. S.A. Empresa De Viacao Aerea Rio Grandense (Varig Airlines),* ____ U.S. ____, 104 S.Ct. 2758 (1984).

The Government now asserts that

> Three issues in this litigation involve discretionary executive functions that should not be within the scope of judicial review:
>
> > 1. The decision by the Office of the Chief of Engineers 'that satisfactory operation of submergible gates cannot be assured, and that they should not be provided at Ohio River Dams until the causes of vibration are known and satisfactory remedial measures are developed' (OCE, September 10, 1964) (Exhibit 554);
> >
> > 2. Operating Procedures for Remote Control of Dam Gates at Markland, Cannelton, Newburgh and Uniontown Locks and Dams, Ohio River (Operations Division, Louisville District, October 30, 1975) (Exhibit 509); and

3. Regulations Governing Operation of Locks and Dams During Ice Periods (Operations Division, Louisville District, January 23, 1978) (Exhibit 519).

Proposed Findings, Doc. 252, at 20.

As to the first of these concerns, the decision by the Chief of Engineers not to include submergible tainter gates in dams built on the Ohio River after September 10, 1964, the decision is properly one insulated from challenge. It was, as was the decision not to include an ice and drift chute in Markland, "the product of research, engineering expertise, and a balancing of competing and opposing factors." *In re Ohio River Disaster Litigation,* 579 F. Supp. at 1282. However, we have found as a fact that the doument (sic) referred to did not constitute a determination by the OCE that submergible tainter gates at then-existing projects could not under any circumstances be used; given that finding, the question of whether the decision not to put such gates in later-constructed projects was discretionary is of virtually no relevance to this litigation.

In addition, because we are persuaded that the submergible tainter gates at Markland had in fact been physically incapacitated prior to the events of January, 1978 — and because that decision, too, carries the earmarks of discretionary function — we need not resolve the issue raised on this point. We think it was likely imprudent to have physically incapacitated the submergible gates. However, that is not something which we review, having concluded that it falls within the purview of the exception and that view does not impact upon our decision herein.

Next, as we have found that the document referred to in the third paragraph — the January 23, 1978 ice regulations — had not been received at Markland until no earlier than January 25, 1978, there is no need to consider whether its drafting was a discretionary function. Because the factual situation which gives rise to our determination that liability lies in this case is

one which developed, insofar as treatment of ice on the river is concerned, prior to that date, the document is simply not one upon which the Government may rely in seeking to justify operational decisions made prior to promulgation of the document.

Of the points raised by the government, then, we address only the question of whether or not promulgation of Exhibit 509 pertaining to remote control of dam gates at Markland and other structures, was discretionary.

The controlling standard for discretionary function analysis, is, of course, that set forth in *Varig Airlines:*

> From the legislative and judicial materials, . . . it is possible to isolate several factors useful in determining when the acts of a Government employee are protected from liability by § 2680(a). First, it is the nature of the conduct, rather than the status of the actor, that governs whether the discretionary function exception applies in a given case. As the Court pointed out in *Dalehite,* the exception covers '[n]ot only agencies of government . . . but all employees exercising discretion.' 346 U.S. at 33. Thus, the basic inquiry concerning the application of the discretionary function exception is whether the challenged acts or a Government employee - whatever his or her rank - are of the nature and quality that Congress intended to shield from tort liability.
>
> Second, whatever else the discretionary function exception may include, it plainly was intended to encompass the discretionary acts of the Government acting in its role as a regulator of the conduct of private individuals . . . . Congress wished to prevent judicial 'second-guessing' of legislative and administrative decisions grounded in social, economic and political policy through the medium of an action in tort.

Varig Airlines, ____ U.S. at ____, 104 S.Ct. at 2765 (first ellipse in original; footnote omitted). Application of the exception to a plan of operation for a Government-owned project does not involve "the Government acting in its role as a regulator of the conduct of private individuals." Our inquiry, then, is whether or not the promulgation of the operating procedure in question was "of the nature and quality that Congress intended to shield from tort liability."

We recognize that in *Dalehite,* 346 U.S. at 36, the Court held that the exception "includes determinations made by executives or administrators in establishing plans, specifications or schedules of operations. Where there is room for policy judgment and decision there is discretion." That language was specifically reaffirmed in *Varig Airlines,* ____ U.S. at ____, 104 S.Ct. at 2764. We further recognize the *Varig* court distinguished *Indian Towing,* 350 U.S. at 61, from the case before it on the basis that "the Government *conceded* that the discretionary function exception was not implicated in *Indian Towing.*" *Varig Airlines,* ____ U.S. at ____, 104 S.Ct. at 2764 (emphasis in original). Nonetheless, in *Indian Towing,* the Court held that once the Government erects a public works project — there, a lighthouse — the Government is then under a duty either to operate the project properly or to warn of the project's incapacity. While the Government's litigation strategy is different in this case than in *Indian Towing,* in that the exception is urged to apply here, we do not believe that the Government has the "discretion" to order that its public works projects be mismanaged. We therefore concluded that, on the facts of this case, our prior holding will control:

> [The plan of operation] was the result of engineering decisions made by Corps personnel. . . . The plan certainly included the weighing of such factors as how to best scour and how to best protect vessels . . . . However, [petitioners] allege that the plan was negligently drawn — that it was, in effect, a 'non-plan' which failed to provide for important

> and obvious steps in the event of an emergency ice condition. The drafting of a daily operations plan is a 'policy' matter in the literal sense of the word. However, we are not able to say . . . that those who drafted the plan had 'the 'power of free decision' ' so as not to be 'bound by tort standards.' *Miller [v. United States,* 583 F.2d 857,] 866 [(6th Cir. 1978)]. This is especially true where, according to the private parties, the plan was formulated without taking into consideration the peculiarities of the situation at Markland.

In re Ohio River Disaster, 579 F. Supp. at 1283-84. Continuing, we noted, and continue to believe, that

> [t]he [G]overnment would have us hold that because [its] . . . inaction was authorized or mandated by the [operations] plan, then it is exempt from suit. We do not read the discretionary function exception as permitting the [G]overnment to skirt liability in such a fashion, just as we do not read *Dalehite* to mandate that, if a middle manager in the Coast Guard in *Indian Towing* had decreed . . . that the lighthouse not be maintained, liability would not attach. Rather, we think that once the [Government] undertook to operate the Markland Dam, it was bound to do so in a fashion dictated by considerations of engineering and managerial prudence.

Id. at 1284. We therefore conclude that the possibility that actions taken at Markland as the ice emergency developed were consistent with operating procedures does not mean that those actions are beyond judicial review.

Although not expressly conceding the point, the Government has not argued in this case that the decision whether or not to shut down the flow of water diverted to the hydroelectric plant was a discretionary function. Nonetheless, because matters of discretionary function effect the Court's subject-matter jurisdiction, we briefly consider the point *sua sponte.*

Senior Corps personnel testified that, during the period here in question, the Corps was under pressure from the Governor of Indiana to maintain maximum output from the Markland generating plant. Power was needed because the United Mine Workers were on strike, and coal was at a premium. Thus, there are overtones of intergovernment relations, matters likely discretionary, which affect consideration of this point.

However, Markland Lockmaster Sheldon testified that he had the authority to cut the amount of water diverted to the power plant down to 5,000 cfs. He did not testify that he had been instructed that the plant must be kept on line, nor did he testify that he was aware that pressure had been brought to bear upon his superiors to maintain the plant at full capacity.

Had the Corps, through, *e.g.*, Mr. Whitlock, either formally or informally ordered that the power plant be fed the maximum amount of water under all circumstances, it is likely that we would see that as a policy determination isolated from challenge by the discretionary function exception. However, because the point was not translated into an operation guideline for personnel at the dam, and because it is unquestioned that as the matter stood in January, 1978, workers at the dam had the authority to cut back flow to the plant, we find that decisions, or omissions, regarding the extent to which water would be diverted to the hydroelectric plant fall outside the purview of the discretionary function exception.

B. Act of God

The Government argues that

> [T]he blizzard had enormous force. It paralyzed the area, and was declared a federal disaster. The National Weather Service issued a Blizzard Warning at 3:45 p.m. on January 25th, and the blizzard arrived a few hours later.
>
> The ice gorge also had enormous force. Seven millions tons of ice held back 50 million tons of water, then this ice

> and water released with almost unbelievable force. And it was unpredictable. the ice began to jam late on the 25th, at the time of the blizzard, and the ice began to dam the river on January 27th.
>
> Plaintiff's (*sic*) meteorological expert, defendant's ice engineering experts, and the Coast Guard concluded that the Ohio River disaster had the elements of an Act of God. A paralyzing blizzard, accompanied by a sudden flood and by formation and release of millions of tons of ice and water, all within 48 hours, is a classic example of an Act of God. If there is an Act of God, this is it.

Proposed Findings, Doc. 252, at 1-2. We adopt the Government's configuration of the elements of the defense: "[A]ny accident, due directly and exclusively to natural causes without human intervention, which by no means of foresight, pains, or care, reasonably to have been expected, could have been prevented." *Id.* at 15, *quoting* 1 C.J.S. 1423. Thus, the elements of a successful *force majeur* defense are:

1. That the occurrence was due to natural causes;

2. That the accident occurred without human intervention;

3. That there were no means to foresee the events which followed.

That the Government wishes to focus exclusively on the blizzard and attendant events, thus shifting attention from the actions of Markland personnel during the first three and one-half weeks of January, 1978, is understandable. The blizzard itself was, as we have found, of extreme force. Accuweather's Mr. Sobel testified that the blizzard was of a force which, although occurring somewhere in the United States perhaps twice each winter, was unusually severe. It may be that were petitioners' damages traceable only to events wholly related to the precipitous weather conditions, an act of God defense would be

meritorious. However, we are unwilling to join in that focal shift. We find as a fact, *infra,* that the gorge occurred as the direct result of inaction by Markland personnel which caused a huge buildup of ice coming down the main stem from Meldahl and from tributaries in the Markland pool which then built upstream from Markland to at least mile 499. We find as a fact that it was reasonably foreseeable that, given the conditions extant in the Markland pool and in the area of Big Bone Island in particular, formation and subsequent breakup of an ice gorge could occur. We have also found as a fact that had available and technically feasible steps been taken at Markland to pass ice through the dam as it arrived — as was required by the ice plans — the gorge would not have occurred. These are acts of human intervention or omission, and those acts in and of themselves are sufficient to defeat the act of God defense as a matter of law.

Because we conclude that the "no human intervention" component of the defense has not been met, we need not consider whether or not the blizzard itself was foreseeable. Nonetheless, we note our view, stated above, that the meteorological charts produced by the Government, Exhibits 317A, 317B, demonstrate that the Corps could, with reasonable monitoring of developing weather conditions, have been aware of the likelihood of a gorge so as to issue warnings to navigators by no later than January 24th or 25th. However, because the Corps had chosen, in contravention of prudent behavior as well as the then-controlling ice plans, to conduct absolutely no surveillance of the Markland pool upstream from Warsaw, the available information would have had little meaning. The Corps created a situation in which it could not intelligently assess the potential hazards created by developing weather conditions, and therefore was unable to foresee what was reasonably foreseeable in the exercise of due care.

We therefore conclude as a matter of law that the defense of *force majeur* is not available to the United States in this case.

C. Negligence

The elements of a cause of action sounding in negligence are that a duty was owed by the defendant to the petitioners, that a breach of that duty occurred, and that the breach proximately caused the damages complained of. The United States vigorously denies each of these elements, and so we consider them *seriatim*.

1. Duty.

Citing a number of cases, the Government argues that the only duty owed by those operating a lock and dam is compliance with 33 C.F.R. § 207.300(a), which provides that

> [t]he lockmaster shall be charged with the immediate control and management of the area, including the lock approach channels. He shall see that all laws, rules, and regulations for the use of the lock and lock area are duly complied with, to which end he is authorized to give all necessary orders and directions in accordance therewith, both to employees of the Government and to any and every person within the limits of the lock and lock area, whether navigating the lock or not. No one shall cause any movement of any vessel, boat, or other floating thing in the lock or approaches except by or under the direction of the lockmaster or his assistances. In the event of any emergency, the lockmaster may depart from these regulations as he deems necessary. The lockmasters shall also be charged with the control and management of Federally constructed morring facilities.

The Government's view, then, is that the only legal responsibility of the Corps of Engineers in operating its public works projects is to govern the conduct of those who have entered the lock approach area, which extends less than a mile up- or downstream of the dam.

Further, the Government asserts that the only real duty which anyone on the river has is the duty of the river pilot. That duty was set forth over a century ago in *Atlee v. Packet Co.*, 88 U.S. (21 Wall.) 389, 396-97 (1875). We do not reproduce the lengthy quotation from *Atlee* provided by counsel, but note that the tenor of the case is that a pilot is "selected for his personal knowledge of the topography through which he steers his vessel," and that "[i]n the long course of a thousand miles in one of these rivers, he must be familiar with the appearance of the shore on each side of the river as he goes along." In sum, the Court noted

> [i]t may be said that this is exacting a very high order of ability in a pilot. But when we consider the value of the lives and property committed to their control, for in this they are absolute masters, the high compensation they receive, and the care which Congress has taken to secure by rigid and frequent examinations and renewal of licenses, this very class of skill, we do not think we fix the standard too high.

Id. at 397. In our view, however, discussion of the duty of a river pilot, whether considered in juxtaposition to that of lock personnel or otherwise, is far more relevant to the question whether petitioners were negligent, than the question of whether the United States has a duty to operate its project within the confines of a particular standard of care.

By the terms of the Suits in Admiralty Act, "[i]n cases where . . . if a private person or property were involved, a proceeding in admiralty could be maintained, any appropriate nonjury proceedings in personam may be brought against the United States . . . ." 46 U.S.C. § 742 (1960). Thus, in terms of analyzing the question of whether the Government may be under a duty to operate its projects within a standard of care, we view inquiry as a rather simple one: Would a private party which owned a lock and dam have a duty to operate its structure within a given standard of care?

In early 1985, we requested briefs from the parties regarding their view on the question of whether the Dam Act of 1906 (34 Stat. 386) as amended by the Dam Act of 1910 (36 Stat. 386) which to impose a duty of due care on private owners or operators of dams in navigable waterways, bears upon this case. Section 3 of the amended Act provides:

> That the person constructing, maintaining, or operating any dam or appurtenant or accessory works, in accordance with the provisions of this Act, shall be liable for any damage that may be inflicted thereby upon private property, either by overflow or otherwise.

Before discussing the relevance of the Act to this case, we note that it does not presently appear as a section of the United States Code. Rather, it is contained in the "Historical Note" prefatory to 33 U.S.C.A. § 361-900 (West Publishing Co. 1970). The Note reproduces the text of the Act, and closes with the statement, "[p]rovisions of said Act have probably been superseded in part by chapter 12 of Title 16, Conservation." The United States takes the position that because the Act is not presently codified, and because it has "probably been superseded in part" by the provisions of the Federal Water Power Act of 1920, 16 U.S.C.A. § 792 *et seq.* (1920), the terms of the Dam Act are of no relevance to this matter. Further, the Government notes, "[o]n the Ohio River . . . there are no private dams." Doc. 255 at 5.

We think that the Government's position on the relevance of § 3 of the Dam Act is wide of the mark. As noted, our inquiry is whether, under the circumstances of this case, "if a private person or property were involved, a proceeding in admiralty could be maintained . . . ." 46 U.S.C. § 742. We agree with petitioners that "[m]indful that the construction and operation of dams within navigable waterways could result in damage to private property, Congress [through the Dam Act] expressly preserved the liability of those constructing the operating dams

in waters of the United States." Doc. 256 at 2. Neither the parties nor the Court have located any Congressional action which would indicated repeal or modification of the terms of the Act, and the supercession referred to in the Historical Note does not suggest otherwise. Thus, we think it remains the law of the United States that a private individual has a duty to exercise due care in the operation and maintenance of its dams spanning navigable waterways, and is answerable in an admiralty court for any damages resulting from a departure from that duty.

In so holding, we do not suggest that the United States may be held liable by virtue of the Dam Act. Rather, we think that the Act merely demonstrates two points: First, that there is a private-sector analogy to the activities of the United States in this case, *i.e.*, that there are, or have been, privately owned and operated dams spanning navigable waters in the United States. Second, that one who operates such a facility is obliged to exercise due care in so doing, or be answerable in a court of admiralty for any damages sustained as a result of a departure from the exercise of due care.

There, too, the Government appears to assert that because those navigating the river are themselves under a high duty to know the river and to navigate it with awareness of developing conditions, it is relieved of responsibility for the consequences of negligent operation of its public works facilities. We have been referred to no case in which it has been held that those operating a dam have no responsibility to do so prudently. This is not, for example, a case such as *Logan Charter Service, Inc. v. Cargill, Inc.*, 373 F.2d 54 (8th Cir. 1967), pertaining to the responsibility of a pilot to navigate prudently while in a lock approach. *See also Alter Co. v. United States*, 412 F. Supp. 73 (W.D. Ky. 1975) (Government not liable for negligence of inexperienced pilot in lock forebay, but was 10% liable for a negligent command given the pilot by lock personnel).

In sum, we do not view this as a case which raises the question of whether a river pilot's own negligence can be excused because

the operator of a lock was also negligent. Rather, its presents, *vis a vis* the issue of duty, the simple question whether the United States has a duty to exercise due care in the operation of its locks and dams. We answer this question, as a matter of law, in the affirmative. *See Transorient Navigators Co., S.A. v. M/S SOUTHWIND,* 714 F.2d 1358, 1364-65 (5th Cir. 1983) and cases cited therein; *see also Eklof Marine Corp v. United States,* 762 F.2d 200, 203 (2d Cir. 1985) (Government has duty to use due care in maintaining the integrity of aids to navigation).

2. Breach.

Our inquiry, then, centers on the question of whether the Government, given the information which was or should have been available to it in the days and weeks preceding the events which gave rise to these lawsuits, operated its locks and dams in a prudent manner consistent with the discharge of a duty of due care.

Defining due care in a situation such as this one is not an easy task. However, in terms of due care in the operation of Markland Locks and Dam, we simply look to the success experienced at other projects, particularly Meldahl, where Corps personnel had success in preventing, through a variety of means, an occurrance such as that at Markland.

In terms of such matters as surveillance and coordination of activities, we are comfortable placing reliance upon a combination of common sense, Corps ice-related documents, and testimony regarding what constitutes "prudent engineering." We especially note Mr. Carigan's testimony, *see supra* at (18); that prudence dictated operational plans which provided for reasonably foreseeable contingencies.

We conclude that the United States did not exercise due care in the following respects:

1. By failing to conduct periodic inspections of the Markland pool during a period when it knew, or should have known, that severe ice conditions were developing and presented potential hazards.

Mr. Whitlock testified that the "ice patrol" regulations, *see, e.g.*, Exhibit 113B, was understood not to apply to high-lift dams, as they do not have sufficient personnel to conduct such surveillance. This assertion proves particularly unconvincing in light of the fact that the Huntington District structures used both air and highway surveillance whenever it was felt necessary; too, Meldahl Lockmaster Dunaway made routine trips up through his pool to check on conditions, simply to satisfy himself as to what he might expect. So, too, Mr. Whitlock testified that he had authority to order overflights to survey the pool. Mr. Whitlock viewed both overflights and shore surveillance as ineffective and unnecessary. Mr. Sheldon viewed information relayed from towboats coming down through the pool as unreliable. Yet those three methods of gaining information were explicitly relied upon by Mr. Dunaway and others in the Huntington District, and surely contributed to their successful handling of ice problems. We think it simply runs counter to common sense and prudent conduct to conclude that no steps need have been taken, in the fact of conditions which indisputably contained the seeds of disaster, to determine what was going on in the many miles of the Markland pool which could not be viewed from the top of the dam — the only surveillance method used. We conclude that the failure to survey the pool was imprudent as a matter of fact, and negligent as a matter of law.

2. By failing to pass floating ice at Markland Dam as it arrived at the dam, whether through use of the underflow gates or otherwise.

The only Corps "ice plan" which was available to Markland personnel during the period prior to January 25, 1978, provided that

> [i]t is apparent . . . that operations to preclude ice hazards should be clarified. Non-moving sheets of ice gives no problem. It is only when ice starts to move under natural conditions (and efforts to move otherwise are of little effect) that hazard is created. *The only safe operation then is to pass all ice through the dam as it arrives, and to have essential provisions for such passage.*

Exhibit 211 at 1 (emphasis supplied). We have found as a fact that ice passed through Meldahl was arriving at Markland no later than January 15th, and probably before then. We have no question but that the ice was "mov[ing] under natural conditions" and should have been passed through the dam via "essential provisions for such passage." Yet it is undisputed that it was not. We determine that failure to have been imprudent and negligent.

3. By failing to periodically restrict the amount of water being diverted to the hydroelectric plant so that additional flow would be available to the dam for ice-passing efforts.

Two undisputed facts are critical to this finding. First, that the hydroelectric plant was permitted to receive the maximum flow available to it throughout the entire period here in question. Second, that lock personnel had the authority to require the plant to shut down to 5,000 cfs of flow. We do not question that was important, given the other problems extant in January 1978, to keep the plant operating as much as possible. We also do not question, however, that the Corps' principal obligation is safe maintenance of Markland as a navigation facility. By permitting the continuous diversion of the maximum amount of water to the hydro plant when a simple telephone call could have made that water available for ice passage for some period or periods each day, the Corps dealt the death knell to any possibility of managing the tremendous amounts of ice which were coming down on the dam.

We also note, in this regard, Mr. Whitlock's own concession that he was "99% sure that [there] would never have been any buildup, never . . . any problems . . ." had the flow to the power plan been diverted to the dam for use in passing ice. (Whitlock trial testimony; Whitlock deposition, Vol. 4, 147-48). While the fact that proceeding differently would likely have averted the casualty does not in itself indicate negligence, we cannot overlook the fact that the individual charged with direct oversight responsibility for Markland operations believes that shutting off flow to the powerplant and using the flows thus made available for ice passage would likely have averted disaster.

We conclude that the failure to use a modicum of foresign in the coordination of powerplant and dam operations was imprudent and negligent.

4. By failing to perform necessary maintenance to ensure that the auxiliary chamber emergency leaf would be available for reasonably foreseeable ice-passing formation.

We recognize that the missing latch pin, which prevented use of the auxiliary chamber emergency leaf for skimming operations until conditions were severe, was not an item which could be purchased at a hardware store. Nonetheless, we do not think that a delay of one and one-half *years* in fabricating and installing the pin embodies the concept of prudent management. This is made doubly clear by the fact that given the operation and physical limitations extant at Markland, no other method of ice passing was available. The parties have stipulated that "[t]he passage of ice through the auxiliary lock as Belleville, Racine and Meldahl helped to maintain navigation in the immediate area of the lock approach" (doc. 219 at ¶ 52). However, it is clear from the experiences at the referenced structures that using the auxiliary chamber to pass ice as continually as possible — interrupted only for ingress and egress of tows in or out of the main chamber — had results which extended well beyond the immediate approach area. By helping to keep the ice moving, it

facilitated far greater success with ice management than occurred at Markland. We think that prudence dictated that the latch pin be replaced as quickly as possible after it was discovered broken, and we conclude that it was negligent not to do so.

5. By permitting the tender boat to become frozen into the auxiliary chamber, thus foreclosing use of the chamber for passing ice once the latching pin was replaced.

We have a great deal of difficulty understanding why this was permitted to occur. The Corps has a responsibility to safely maintain its physical plant and appurtenances. At the Markland site, there is a sheltered area shoreward from the auxiliary chamber which is routinely used for storage of the floating plant. Markland personnel could undoubtedly have readily determined when the latch pin would be replaced. It was imprudent to have allowed the auxiliary chamber to have become wholly immobilized by permitting a propellerless boat to be frozen in the chamber. We find no rationale for this action in the context of the limitations extant at Markland, and conclude that it was negligent to permit it to happen.

6. By failing to train lock personnel in available means of passing ice at low flows.

It appears that, from the outset, Markland personnel were simply left to their own devices regarding how to proceed in ice conditions. As a result, they were woefully unprepared for the events of January, 1978; Meldahl personnel responded quickly and creatively, while Markland personnel simply stood by and watched. We think that with proper training (Lockmaster Sheldon testified that he had none save "on-the-job"), appropriate steps could have been taken as conditions developed, and we conclude that the failure to train was negligent.

7. By failing to coordinate efforts between Markland Locks and Dam and facilities upstream of Markland, particularly Meldahl, with regard to the continuous passage of ice through

Meldahl into the Markland pool after the time at which it became apparent that Markland was facing development of potentially hazardous ice circumstances.

The officer in charge of the Louisville District called his superior at the Ohio River Division on January 23rd, and told him that ice was becoming a serious problem at Markland. That superior, with oversight responsibility and authority over the entire river, called the office in charge of the Huntington District. He was told that Meldahl was doing what it had to to manage its problems, and would not alter its plan of operation. That determination was simply accepted, and the Markland Lockmaster was never appraised of either the conversations or their result. We think it clear that either Markland should have been apprised of the fact that Meldahl was passing ice as fast as it could, and told how to attempt to do the same, or Meldahl should have been ordered to stop passing ice for a period long enough for Markland to make some progress with the already enormous amount of ice present upstream from the dam. We conclude that this abdication of oversight authority was imprudent and negligent. *See, e.g., Southern Natural Gas Company v. Puntchatrain Materials, Inc.*, 711 F.2d 1271, 1258 (5th Cir. 1983).

8. By failing to maintain the structure in a condition which would, following the incapacitation of the submergible tainter gates, permit underflow passage of ice at relatively low flows.

The Corps witnesses were in agreement that, in 1978, they could not be sure whether the stone protection downstream from the dam was sturdy enough to withstand underflow passage of ice at low flows. For years, the dam had been, as a policy matter, handicapped by being forbidden to use the submergible tainter gates. After those gates were incapacitated, we think that reasonable prudence dictated that steps be taken to ensure that Markland could conduct underflow passage operations whenever flows were sufficient to permit

hydraulically adequate gate openings. Again, we note the success experienced at Meldahl through intelligent use of underflow configurations, "walking the gates," and the like, and we think it was imprudent and negligent for steps not to have been taken to ensure that Markland was not completely crippled by the admittedly foreseeable events of low flows and heavy ice.

Because we have concluded that the operation of Markland Dam and other aspects of Government conduct in this case were negligent, and as we conclude below that the negligence found was a proximate cause of petitioners' losses, we do not address petitioners' claims that the Government may be held liable for failing to have warned petitioners of the possibility that an ice gorge might form and cause damage.

3. Causation.

We turn to the question of whether or not the departures from prudent operation of Markland Dam identified above proximately caused or substantially contributed to petitioners' losses. *See United States v. Reliable Transfer Co., Inc.*, 421 U.S. 397 (1975).

The principal causation witnesses were Mr. Lazier on behalf of petitioners and Dr. George Ashton on behalf of the United States. The parties have adopted the shorthand terms of "progression theory" for the hypothesis advanced by Mr. Lazier, and "clogging theory" for the hypothesis advanced by Dr. Ashton.

As set forth in petitioners' proposed findings,

> The Petitioners' theory as to how the ice formed and grew to a point where it became unmanageable, was referred to in the testimony is the 'progression theory' . . . . [T]he ice which arrived at Markland between the 16th and the 27th of January, 1978 stopped at the structure, and began to propagate, or 'progress' upstream as a solid bank-to-bank ice cover which ultimately made its way up

to Big Bone Island where it received additional structural supported from the island.

* * *

Once the ice jam had progressed to Big Bone Island, the additional structural support provided by the island permitted it to become a very significant ice jam, and ultimately, a gorge, which actually dammed the river at that point.

All of the ice experts agree that when ice stops in the river, and in turn, supports the stoppage of other ice, that situation constitutes a 'jam.' Hence, all concur that there was a jam at Markland, and a significant continuing upstream progression.

The reason the Corps of Engineers' ice regulations warn that the only safe thing to do is to keep the ice moving is that doing otherwise will permit a jam to build, progress, and increase in significance to the point where it could become a gorge.

The ice experts offered by the Petitioners have stated that in their opinion the ice stopped at Markland because of a failure to pass the ice during periods of low flows; that the resulting jam continued to propagate or progress upstream to Big Bone Island, and that during the period between the 16th and 27th of January, the progression of the jam grew and increased to the point where it became a gorge and blocked the flow of water which was released from Meldahl during the night of the 26th and morning of the 27th of January. All of this was initiated by the simple failure of the Corps employees at Markland to do what its own regulations and ice plan required — pass the ice as it arrived at the dam.

Petitioners' Proposed Findings at 27-28. In short, Mr. Lazier testified that ice built from Markland all the way up to or

beyond Big Bone Island, and that the buildup created a base for the gorge which resulted from increased flows and attendant increased velocities. Thus, the inaction at Markland was, in Mr. Lazier's opinion, causally related to formation of the gorge.

As set forth by the United States, the "clogging theory" is as follows:

> There is a natural constriction in the Ohio River at mile 502, Laughery Island, and mile 517, Big Bone Island. Charts Nos. 93 and 95. These constrictions have the potential to retard the flows of ice.
>
> On January 20th, ice was flowing through Markland, and on January 21, it was stopped. On January 22nd, bank-to-bank ice was reported from mile 509. Ice Committee Report, Appendix I, Exhibit 6, at 2. This report did not indicate the course, the speed of the ice movement or the distance downstream. Then, on January 23d, there was a substantial open area above mile 528, according to Norb Whitlock, Larry Dickson and Norman Ivey, and a substantial accumulation at mile 499, where plaintiff's towboat stalled.
>
> These observations, considered together, suggest a sequence of constriction and release. With distances of man miles, moving ice, open areas and a limited period of time, there is no basis for a conclusion that ice stopped at the dam on January 21st and backed up 32 miles, to mile 499, by January 23rd.
>
> The ice differed from area to area. There was open water, partial coverage, compieted overage, moving ice, stationary ice, light ice, heavy ice and ice distributed and broken up by towboats. This does not add up to a structure with strength and integrity to back up to mile 517, Big Bone Island, or to mile 499. It is clear, from the facts of this case, that the ice shifted and compacted on January

26th to increase this integrity, and that this integrity became sufficient to jam the river only on January 27th.

Kennedy, Frankenstein and Ashton provided facts, reasons and experience to support their conclusion that the gorge at mile 515 formed at a natural constriction. In particular, George Ashton noted moving ice and open areas near the dam at the same time ice was moving above the two islands; the tendency, based on Froude numbers, for any ice backed up at the dam to stop and collect at a point a few miles above the dam, rather than continue to back upriver; the nature of the ice with small pieces and frazil ice, rather than a sheet with integrity; the thaw, warmer weather an (sic) rain, on January 23rd through 25th, to weaken any accumulation of ice in any river; and the absence of support from the dam. When defendant's experts' analysis is compared to the speculation that ice may, at some unspecified time, have backed up to Big Bone Island and miles beyond, it is clear that the natural explanation, with ice accumulating at a constriction, is also the probable explanation.

Ashton testified, and plaintiffs' (sic) expert agreed, that the dam would provide structural support for an ice accumulation for approximately two or three miles. Above that distance, an accumulation finds its support from its own structure and its connection to the river banks. If ice accumulates above that distances, any ice at the dam may be removed without disturbing that accumulation above.

United States' proposed findings, March 7, 1985, at 69-71.

In considering these arguments, we first note that it is true that the experts generally agreed "that the dam would provide support for an ice accumulation for approximately two or three miles." *Id.* We fail, however, to see much significance to this point. The issue is whether or not Markland was operated in such a way as to facilitate the buildup or ice upstream to or past

Big Bone Island. If in fact that occurrence was permitted, it makes little difference whether "any ice at the dam [could] be removed without disturbing the accumulation above." We also find a factual discrepancy in that contention. The records from Meldahl, Belleville and Racine Locks and Dams are clear that by using all available means of passing ice, personnel at those projects were able to pass literally miles of ice through their projects. Whether this was accomplished by passing moving ice as it came down on the dam, as required by Corps policy, or — as appears to be the case at some points during the time in question — by restarting ice which has stopped moving, the strategy was effective and did not result in passage of only that ice nearest to the dam. Thus, we do not accept the testimony of the experts to the limited extent that they opined that ice more than three miles upstream could under no circumstances be jogged free by starting movement in the ice at the dam.

The Court is unable to accept the "clogging" theory advanced by Messrs. Ashton, *et al.*, for several reasons. The first stems from the following undisputed acts. Each dam upstream from Markland was passing huge amounts of ice through the dam. The Meldahl ice summary reports accumulation of "an ice pack which extended . . . . 8 to 10 miles upstream of the dam" on January 16th. That ice was continually passed through the dam and the auxiliary chamber, to the point that, as reflected in stipulated Table 2 (doc. 219 at ¶ 18), there was no ice at the dam on the 24th. However, not only was Meldahl passing ice that had accumulated in its ice pack by the 16th. It is clear that ice was continually forming in the river, coming down from upstream structures, and forming in tributaries throughout the period prior to January 23rd or 24th. Thus, the eight to ten miles of ice reported on the 16th would represent only a fraction of the ice passed through Meldahl.

There is no question but that virtually all ice passed through Meldahl ended up in the ice pack above Markland. In addition, of course, ice was forming in the Markland pool, and additional

ice was coming into the main stem from tributaries in the Markland pool, such as the Licking, Little Miami, and Great Miami Rivers. Assuming that this ice formed as something akin to the rate it formed at Meldahl — admittedly a rough estimate — then there may have been eight to fifteen miles of ice which formed in the Markland pool, *in addition* to the ice which was coming downstream from Meldahl.

All this ice — ice coming through Meldahl, ice coming from tributaries, and ice forming in the Markland pool — had to go somewhere. It is undisputed that no significant amounts of ice were passed through Markland at any point during this time. The Government's position is that the large distance and relatively short time involved "suggest a sequence of constriction and release." That assertion, however, is based entirely on the hypothesis that "[o]n January 20th, ice was flowing through Markland, and on January 21, it was stopped." This observation, taken from Mr. Whitlock's report to the Ice Committee, is not one which we can reconcile with the undisputed facts that, at Markland, ice covered 80% of the river on January 16th and 17th, and 100% of the river from the 18th on — and that no ice was passed through the dam. As found above, we discredit that statement, finding instead that ice was stopped at Markland no later than January 18th or 19th.

Given these facts, and largely accepting Mr. Lazier's testimony, the evidence leaves us with no question that it is more likely than not that ice had built up to at least mile 517, and probably to mile 509 (as reported on January 22) or above, by no later than the 22nd or 23rd.

As noted by petitioners,

> The [G]overnment's chief ice expert, Dr. George Ashton, an ice engineer from the Corps' Cold Region Research Engineering Laboratory, stated his agreement with the following:

> (A) That there was bank-to-bank ice stopped at Markland early in the period of the 16th through the 27th, which constituted a 'jam';
>
> (B) That arriving ice stopped at the jam and propagated or progressed upstream toward Big Bone Island;
>
> (C) That the progression of the jam continued, although he cannot state how far or how long;
>
> That the 'progression' theory is not inconsistent with the 'clogging' theory which is preferred by Dr. Ashton as an explanation for the formation and breaking of the gorge.

Petitioners' Proposed Findings at 29. In other words, the primary exponent of the "clogging theory" conceded, we conclude, every element of the "progression theory" advanced by Mr. Lazier. Because we find that the progression analysis is, given the largely undisputed events of the period beginning January 16th, the more reasonable view, we find as a fact, and conclude as a matter of law, that the various acts of negligence identified above which permitted ice to accumulate at Markland and build upstream unimpeded were the proximate cause of the formation of the ice gorge at Big Bone Island.

We further conclude that formation and collapse of the ice gorge were reasonably foreseeable events. While, as noted, the storm itself was of severe magnitude, we find as a fact that the extent of the rise in the river — the causal event *vis a vis* the gorge — was not especially fast; Mr. Mitchell, Chief of the ORD's Reservoir Control Center in Cincinnati, testified that a rise of the magnitude here experienced occurs, on the average, every two years.

Although the relevant findings regarding our determination that the progression theory most nearly describes the phenomena which led to the formation of the ice gorge at Big Bone Island are set forth above, we summarize the relevant facts:

1. From no later than January 16, 1978, ice was coming downstream to Markland.

2. At no time were substantial amounts of ice passed through Markland; large amounts of ice were continually passed through Meldahl into the Markland pool.

3. Ice was permitted to accumulate just upstream from Markland, and no substantial steps were taken to diffuse the buildup. Once ice built up about three miles from Markland, it bridges across the river and provided additional lateral support for additional upstream buildup.

4. On or before January 23, ice had built up at least 32 miles upstream from the dam, to approximately mile 499.

5. That buildup, reported by Mr. Whitlock himself, is entirely consistent with the fact that large amounts of ice had been passed through Meldahl, while no ice was passed through Markland. In short, all that ice had to stop somewhere, and Markland was the place.

6. Big Bone Island was located at river mile 517, 18 miles downstream from the upstream edge of the ice at about mile 499.

7. Big Bone Island provided a constriction in the river which served to stop ice being forced downstream toward Markland by higher river flows, because ice was, as found above, built up from Markland to well past the island.

8. Had Markland passed ice as it came downstream, as required by Corps' ice policy, it is more likely than not that no gorge would have formed at Big Bone Island.

9. It was reasonably foreseeable that heavy ice might form in the Ohio in January.

10. It was reasonably foreseeable that if ice were permitted to build up, a gorge might occur at a location similar to that of Big Bone Island.

11. It was reasonably foreseeable that a rise in flows of the magnitude which in fact occurred in this case would occur.

12. While "clogging" occurred at Big Bone Island, absent the downstream support provided first by Markland and then by ice which would not have accumulated but for Markland, the "clog" would not have occurred.

13. Failure to pass ice through Markland proximately caused the ice gorge at Big Bone Island.

VI. DAMAGES

We now address issues of damages. Petitioners each settled the claims filed against them by their bailors; Walker settled $2,185,620.68 in claims for $1,500,000.00, and B-R River Services settled claims totalling $2,284,556.16 for $1,423,299.00. The United States has stipulated that the amounts paid out were reasonable under the circumstances, and we have already determined that damages were proximately caused by negligence on the part of the defendant. We therefore need only address the question whether petitioners are entitled to recover from the United States.

Petitioners assert that their entitlement to recover damages in the situation at bar is governed, in this Circuit, by *Tankrederiet Gefion A/S v. Hyman-Michaels Company,* 406 F.2d 1039 (6th Cir. 1969). In *Tankrederiet,* the court held that a party seeking indemnity from the United States but wishing to settle, prior to trial, with its bailors, must tender the defense of its claims to the defendant in exchange for a hold-harmless agreement:

> It certainly seems appropriate for . . . the party desiring to settle and possessing the facts pertaining to the settlement, to be required to tender . . . the choice of approving the settlement or of going forward with the defense in exchange for a hold-harmless agreement . . . . If such a tender were refused and [petitioner] settle, then we

> think the proofs required in the subsequent suit . . . would appropriately be potential liability and reasonableness of the settlement.

Id. at 1043. We agree with petitioners that the case controls, and examine their actions to determine whether recovery lies.

Walker Towing did tender the defense of the claims against it to the United States, and the tender was refused. The Government has stipulated that the settlement was reasonable. The only issue we must address regarding Walker, then, is whether it had "potential liability" in these cases so as to entitled it to recover as against the Government. Both parties' positions on this point are somewhat difficult conceptually; the Government urges that, while it believes Walker was contributorily negligent by virture of the manner in which the AGNES MAE was secured, no potential liability was shown, while Walker, while denying any negligence on its part, must argue that it was in fact potentially liable.

We conclude that Walker Towing may have been potentially liable for the damages sustained by its bailors, and hence that, given that the damages were proximately caused by negligence on the part of the party against which indemnification is sought, recovery lies. We observe that, had the Government *not* been found liable here, Walker would almost certainly have been itself liable, given that we have concluded that the damages were not sustained as the result of an act of God. Walker's case against the Government was difficult and the result was far from certain prior to trial. We therefore conclude that Walker is entitled to recover the amount of $1,500,000.00 together with interest from the date or dates upon which settlement monies were disbursed.

As to B-R, the situation is somewhat more complex. Clearly, as we have determined that B-R was 60% responsible for the casualty, its "potential liability" is well established. However, B-R did not tender its defense or the proposed settlement to the Government. B-R asserts that

> [t]he United States suggested to the Court at the close of the discovery period . . . that B-R River Services go ahead and make settlement with its claimants, leaving a trial on the indemnity issue against the United States.
>
> Because of this suggestion by the United States, B-R River Services initiated settlement discussions with the original claimants. B-R asked the United States if it wished to participate in these negotiations but the United States refused. B-R's negotiations were also prompted by Judge Porter's opinion denying the M/V Bill Edwards' motion for summary judgment which identified the potential liability of the vessel and the fleet.
>
> Before B-R River Services reached a settlement with the claimants, Walker Towing Company tendered its defense to the Government in exchange for a hold harmless agreement, but the Government refused to accept it. Walker Towing Company's claim against the United States is almost identical to B-R River Services' claim against the United States. Given the futility of making a tender of defense to the United States after the United States had already refused a similar tender, B-R River Services concluded a settlement with the claimants totalling $1,423,299.00 . . . .

Proposed Findings at 83.

Thus, B-R did not comply with the terms of *Tankrederiet*, in that it did not tender the defense of the claims against it to the Government. Upon reflection, we conclude that to deny recovery in this situation based upon strict adherence to the terms of *Tankrederiet* where, as B-R points out, the Government urged the settlement and declined to participate in it — and has stipulated to the reasonableness of the settlements — would elevate form over substance. We therefore conclude that, to the extent recovery is appropriate under the terms of this decision, B-R is entitled to recover from the United States.

B-R has also filed an amended complaint seeking to recover the full amount of the claims against it — substantially more than the amount for which it settled — from the Government, based upon B-R's rights as a bailee. We see no merit to B-R's position in this regard, and dismiss that portion of the amended complaint.

In accordance with the foregoing, judgment is hereby entered in favor of petitioner Walker Towing Company, Inc. and against the United States, in the amount of $1,500,000.00 together with interest from the date or dates of disbursement. Judgment is entered in favor of petitioner B-R River Services, Inc., and against the United States, in the amount of $569,319.60, together with interest from the date or dates of disbursement.

The parties are asked to submit short supplemental briefs on the question of attorney's fees, unless the matter can be resolved as between the parties. The Court should be advised if discussions appear potentially fruitful within ten days after filing; if such is not the case, briefs should be exchanged within twenty days.

In closing, the Court wishes to commend and thank all counsel in this case for having done an exceptional job of preparing and presenting an extremely difficult case.[5] All

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[5] The Court also wishes to thank Senior Judge David S. Porter and his law clerk, Frederick Morgan, Esq., for their part in this case; Judge Porter for continuing settlement negotiations long after his official involvement herein ceased and for permitting Mr. Morgan to lend his services, and Mr. Morgan for excellent assistance in the disposition of these cases.

clients were well-served, and little more could have been done by anyone involved to professionally present the various sides of the questions raised.

Judgment will enter accordingly.

SO ORDERED.

/s/ S. Arthur Spiegel
United States District Judge

AMENDED JUDGMENT IN A CIVIL CASE

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF OHIO
WESTERN DIVISION AT CINCINNATI

Docket No. C-1-78-0075, C-1-79-0002, C-1-79-0208,
C-1-80-0028, C-1-80-0591, C-1-80-0592
C-1-81-414, C-1-84-0477 MDL 420

Honorable S. Arthur Spiegel

IN THE MATTER OF THE COMPLAINT OF WALKER TOWING CORPORATION FOR EXONERATION FROM OR LIMITATION OF LIABILITY

Consolidated with

IN THE MATTER OF THE PETITION OF B-R RIVER SERVICES
(N.D. Ky. C78-0217-L)

(Filed September 26, 1985)

☐ **Jury Verdict.** This action came before the Court and a jury with the judicial officer named above presiding. The issues have been tried and the jury has rendered its verdict.

☒ **Decision by Court.** This action came to trial or hearing before the Court with the judge (magistrate) named above presiding. The issues have been tried or heard and a decision has been rendered.

IT IS ORDERED AND ADJUDGED

that judgment is entered in favor of petitioner Walker Towing Company, Inc. and against the United States in the amount of ONE MILLION FIVE HUNDRED THOUSAND DOLLARS ($1,500,000.00) together with interest from the date or dates of disbursement. Judgment is entered in favor of petitioner B-R

River Services, Inc. and against the United States in the amount of FIVE HUNDRED SIXTY-NINE THOUSAND THREE HUNDRED NINETEEN DOLLARS AND SIXTY CENTS ($569,319.60) together with interest from the date or dates of disbursement.

Clerk

Kenneth J. Murphy, Jr.

Deputy Clerk

/s/ Elizabeth Schaeffer Date 9/26/85

United States District Court
Southern District Of Ohio
Western Division

No: C-1-79-208
MDL-420

IN THE MATTER OF THE COMPLAINT OF WALKER TOWING CORPORATION, A CORPORATION FOR EXONERATION FROM OR LIMITATION OF LIABILITY

Consolidated With

United States District Court Western District of Kentucky at Louisville

IN THE MATTER OF THE PETITION OF B-R RIVER SERVICES

No: C78-0217-L(J) (ETC)

AMENDED OPINION AND ORDER

(Filed September 27, 1985)

SPIEGEL, J.:

It appearing that a typographical error was included on the fourth page of the Opinion in the last line in that the amount B-R River Services, Inc. is entitled to recover was stated as $711,649.50, when the correct amount of losses that B-R River Services is entitled to recover is $569,319.60, it is hereby Ordered that the attached page four should be substituted for the original page four as it corrects the aforesaid typographical error.

SO ORDERED.

/s/ S. Arthur Spiegel
United States District Judge

II. SUMMARY OF HOLDING

For reasons which follow, we find and conclude that the United States was negligent in several aspects of its operation of facilities owned and operated by it, through the Army Corps of Engineers. The gist of the negligence findings are that the Government, under a duty to use due care in the operation of its locks and dams, breached that duty by, *inter alia,* failing to pass ice through Markland Locks and Dam as the ice came downstream during the middle weeks of January, 1978; failing to engage in routine surveillance of the reaches of the Ohio River upstream from Markland; failing to train its personnel in methods of handling and evaluating ice conditions; failing to ensure that the dam was in fact capable of dealing with reasonably forseeable ice conditions; and failing to intermittently restrict diversion of river flows to a hydroelectric generating facility located on the Markland site so that ice could be passed through the dam.

We also conclude that the acts or omissions detailed herein constitute deviations from the appropriate standard of care and were a proximate cause of the damages sustained by petitioners Walker Towing Company, Inc. and B-R River Services, Inc. However, we conclude that B-R River Services, Inc., was itself negligent, and attribute to that petitioner sixty percent of the responsibility for its recoverable losses.

Finally, we conclude that Walker Towing Company is entitled to recover for its losses in the amount of $1,500,000.00, and B-R River Services, Inc. is entitled to recover for its losses in the amount of $569,319.60; both together with prejudgment interest at

SECOND AMENDED JUDGMENT IN A CIVIL CASE

(Filed October 10, 1985)

United States District Court
Southern District Of Ohio
Western Division At Cincinnati

Docket Number: C-1-78-0075, C-1-79-0002, C-1-79-0208, C-1-80-0028, C-1-80-0591, C-1-80-0592, C-1-81-0414, C-1-84-0477, MDL 420

Honorable S. Arthur Spiegel, Judge

IN THE MATTER OF THE COMPLAINT OF WALKER TOWING CORPORATION FOR EXONERATION FROM OR LIMITATION OF LIABILITY

Consolidated with

IN THE MATTER OF THE PETITION OF B-R RIVER SERVICES
(N.D. Ky. C78-0217-L)

☐ **Jury Verdict.** This action came before the Court and a jury with the judicial officer named above presiding. The issues have been tried and the jury has rendered its verdict.

☒ **Decision by Court.** This action came to trial or hearing before the Court with the judge (magistrate) named above presiding. The issues have been tried or heard and a decision has been rendered.

IT IS ORDERED AND ADJUDGED

that judgment is entered in favor of petitioner Walker Towing Corporation and against the United States in the amount of ONE MILLION FIVE HUNDRED THOUSAND DOLLARS ($1,500,000.00) together with interest from the date or dates of disbursement. Judgment is entered in favor of petitioner B-R River Services, Inc. and against the United States in the amount

of FIVE HUNDRED SIXTY-NINE THOUSAND THREE HUNDRED NINETEEN DOLLARS AND SIXTY CENTS ($569,319.60) together with interest from the date or dates of disbursement.

Clerk

Kenneth J. Murphy, Jr.

Deputy Clerk

/s/ Elizabeth Schaeffer Date 10/10/85

U.S. ARMY ENGINEER DIVISION, OHIO RIVER
CORPS OF ENGINEERS
315-335 Main St.
Cincinnati 1, Ohio

ORDEN

Regulation
No. 1130-5 7 February 1964

PROJECT OPERATION

Ice Conditions on Non-Navigable Type Dams

1. **Purpose and Scope.** The ice conditions which have occurred in recent years give cause to alert those responsible for operations of the non-navigable type dams.

2. **Reference.** OVDVA letter dated 10 June 1957, subject: "Design Memorandum No. 14, New Cumberland Locks and Dam, Ohio River, (letter from Pittsburgh District to ORD dated 8 January 1957)."

3. The following extract from the referenced letter provides some guidance:

> "It is apparent from the views stated that operations to preclude ice hazard should be clarified. Non-moving sheet ice gives no problem. It is only when ice starts to move under natural conditions (and efforts to move otherwise are of little effect) that a hazard is created. The only safe operation then is to pass all ice through the dam as it arrives, and to have essential provisions for such passage. Such movements generally follow the thalweg of the

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This regulation supersedes Regulation No. 1130-1 dated 13 February 1963

[Plaintiff's Exhibit 211]

stream. Movements during low flow can be passed over one gate (7 to 8,000 cfs at 7 feet depth). Increased flows with ice would be passed over other adjacent gates. Any tendency for skimming of ice by underflow gates should be discouraged. The opening required for passage of ice by underflow will vary with the ice formation and tailwater-head relations. An assured passage may be 50 percent opening, which in this project would pass 26-30,000 cfs per gate. Failure to pass one-inch thickness of ice can form a serious gorge, and such has happened on one occasion through operational failure to provide passage of it. Fluctuations in pools are not contemplated, but minor ones may result under some conditions of passing ice on arrival."

4. Overflow submergible gates have been provided to pass ice and debris until tailwater builds up sufficiently to permit safe under-gate passage. Concentration of heavy flows with low-tailwater for under-passage is not contemplated. In fact, the apron design does not provide for such condition and the stone protection is provided to give a delaying action against scour if such operation should become necessary for short periods. Under certain conditions, such as nonavailability of submergible gates during construction or some other reason, it may be necessary to place upstream bulkheads to within 7 or 8 feet of upper pool and completely raise a gate.

5. Economy has dictated various founding conditions for gate sills at different sites. Some rest on the pier bases, with seepage cutoff provided by steel sheet piles. Others have sills carried to rock with the apron founded on steel bearing piles. Short steel sheet piles have been provided along the downstream of the aprons to give an added precaution against quick loss of material in case the protection stone is lost. These sheet piles have very limited strength against earth and water pressure if the supporting soil is removed. Such loss may cause the loss of a sill and/or apron. It is, therefore, necessary that operations be so

arranged that hazardous downstream scour is prevented. Obviously, progress of any development of scour should be closely followed to permit timely remedial action when indicated.

6. It is requested that the above be brought to the attention of all personnel concerned with the design, construction, and operation of the non-navigable type dams.

7. In the event action is taken to pass ice at a non-navigable type dam, it is requested that a report thereon be made promptly to this office. All pertinent data should be included, such as: character of ice, volume of river flow, how the passage was accomplished, gates used, difficulties encountered, damage sustained, etc. Appropriate photographs showing conditions, operations, etc. should be included. Any suggestions you may have to make on design, arrangement and operation are desired.

FOR THE DIVISION ENGINEER:

/s/ R. W. de LANCEY
Colonel, Corps of Engineers
Deputy Division Engineer

DISTRIBUTION:

B - 12 cys ea Dist
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U.S. ARMY ENGINEER DIVISION, OHIO RIVER
CORPS OF ENGINEERS
315-335 Main St.
Cincinnati 1, Ohio

x800.911 (Div Bulletins)
x821
x300.5 (Div Circular)
x800.211

OVDVK
828.1 (Ice Conditions) 14 October 1958

File Copy Rec - 1-14-77 (in script)

DIVISION CIRCULAR NO. 16-58

EFFECTIVE UNTIL 14 OCTOBER 1960 UNLESS
SOONER RESCINDED OR SUPERSEDED

Effective date extended to 14 Oct. 62 by all Dist (in script)

SUBJECT: Operation of Locks and Dams and Other Activities During Ice Periods.

TO: All District Engineers
U.S. Army Engineer Division, Ohio River

FIVE COPIES TO EACH

1. The following general instructions are issued to govern the lock and dam operation, patrols, collection and reporting of data, in all districts during critical ice periods:

a. When severe ice conditions seem imminent, the maneuverboat at each of the movable dams shall be placed along the outside of and near the upper end of the river wall above the dam or within the lock chamber, if traffic permits, well in advance of dangerous conditions. Necessary steps shall

be taken to insure that the maneuverboat can be placed below the dam in ample time to lower the dam and in no case shall the maneuverboat remain out on the dam during an ice run.

b. The dam shall be lowered by the maneuverboat from below, and it is desirable to break the dam by lowering from three to five wickets adjacent to the beartrap pier before actual lowering operations are commenced. The flow through the opening made by the three to five wickets adjacent to the beartrap pier may be counteracted, if necessary, by the manipulation of one or more traps in order to hold the upper pool within one to two feet of normal level.

c. The pool shall be kept below the crest of the dam in face of continued freezing temperatures. No attempt shall be made to pass ice over the dam. However, in order to meet the requirements of navigation, every effort shall be made to prevent the upper pool from falling below needed navigable depths.

d. If the dam is down and there are scattered wickets partly raised due to breeching or other cause, green instead of red navigation lights shall be displayed on the lock walls to warn navigators that they must either use the lock or stop for information in regard to the exact location of these wickets before using the pass.

e. The Operation Division of this office is to be consulted prior to the lowering of dams for ice passage in order that such operation can be coordinated with other districts.

f. When the dams are lowered, the lock gates shall be open and fastened securely in their recesses, unless floating plant using the protection of the gates as an ice harbor is moored below the lock.

g. Flasher buoys, pass buoys, swinging pole lights, etc. shall be removed from all lock walls and piers to prevent damage during the ice periods, but they shall be replaced as soon as conditions permit and navigation interests shall be advised of their removal or replacement immediately.

h. Wherever possible, the crew at each lock shall be kept at full strength.

i. In order to facilitate the movement of navigation while the dam is in operation, the ice forming in the approaches and around the gates shall be kept broken and the gates maintained free of ice as far as practicable by use of the maneuverboat and by lockage of ice from the upper to the lower pool. Extreme care must be exercised by personnel when operating the gates in order to prevent damage to the leaves and operating mechanism. Tows using the lock must not be permitted to rub against the gates when they cannot be properly placed in the gate recesses.

j. When sub-freezing temperatures and the formation of ice make it hazardous to navigate the pool and it is probable that conditions will become worse, navigators in the area should be warned to seek safety immediately in an ice harbor. All practical warning, advice, and assistance shall be given to navigation interests.

k. At locks and dams where repair work is in progress that requires manipulation of any part of the structure to pass water and ice, such repairs should cease until the ice condition clears up.

l. Information on ice harbors and regulations governing their use should be prepared and furnished navigation interests by the middle of December, 1958. Corrected information should be furnished in succeeding years, preferably in December.

m. Ice patrols should be established whose duties are as follows:

(1) To collect pertinent information concerning ice gorges.

(2) To collect data on damages to structures and plant owned by both the U.S. Government and private interests.

(3) To relay pertinent information to the District Engineer.

(4) To take photographs.

(5) To collect other information desired by the District Engineer.

n. Daily informatory teletypes or radiograms shall be sent to the Division Office when ice conditions warrant it. Such messages will report the location and condition of commercial tows, condition of movable dams, locations of ice gorges, and any other important information.

/s/ W. W. LAPSLEY
Brigadier General, USA
Division Engineer

DEPARTMENT OF THE ARMY
Louisville District Corps of Engineers
P. O. Box 59
LOUISVILLE, KENTUCKY 40201

ORLOP-W January 23, 1978

SUBJECT: Regulations Governing Operation of Locks and Dams During Ice Periods and Reporting Ice Conditions

TO: Ohio River Lockmasters
Louisville District

1. During the period of cold weather, Lockmasters shall observe closely the formation of ice in their pools and utilize the following instructions insofar as possible. Deviations from these instructions shall be coordinated with the District Office.

a. **Markland, McAlpine, Cannelton, Newburgh, Uniontown and Smithland Locks and Dams.**

When ice conditions seems imminent, the floating plant at each of the non-navigable type dams shall be placed within the auxiliary lock chamber, if traffic permits, well in advance of dangerous conditions.

The pool shall be kept at or near the normal pool elevation insofar as possible. However, in order to provide some flow in the river to reduce the formation of ice, the upper pool may vary plus or minus one foot.

Non-moving sheet ice gives no problems. It is only when ice starts to move under natural conditions that a hazard is created. The only safe operation then is to pass all ice through the dam as it arrives. The opening required for passage of ice by underflow will vary with the ice formation and tailwater-head relations. An assured passage may be 50 percent opening. Because of the various founding conditions for gate sills at different sites, it is

therefore necessary that operations be so arranged that hazardous downstream scour is prevented. Under certain conditions, it may be necessary to place the upstream bulkheads to within 7 or 8 feet of the upper pool and completely raise a gate.

Whenever a dam tainter gate is to be raised or lowered, it is mandatory that the ice in front of that gate be broken up and that the gate be raised or lowered manually from the gate site.

In order to facilitate the movement of navigation and keep the locks open, the ice forming in the approaches and around the gates shall be kept broken and the gates maintained free of ice as far as practicable by use of the tender, commercial towboats, tows and by lockage of ice from the upper to the lower pool. Extreme care must be exercised by all personnel when operating the gates in order to prevent damage to the gate leaves and operating mechanism. Tows using the lock must not be permitted to rub against the gates when they cannot be properly placed in the gate recesses.

At times when ice is forming in the river and on the dam, daily inspection of the lock and dam shall be made by the Lockmaster or the Assistant Lockmaster and the conditions found shall be reported to the District Office.

In the event it becomes necessary to pass ice at a non-navigable type dam, it is requested that such action be closely coordinated between the field and the District Office.

b. **Locks and Dams Nos. 50, 51, 52 and 53, Ohio River.**

When ice conditions seem imminent, the maneuverboat at each of the movable dams shall be placed along the outside of and near the upper end of the river wall above the dam or within the lock chamber, if traffic permits, well in advance of dangerous conditions. Necessary steps shall be taken to insure that the maneuverboat can be placed below the dam in ample time to lower the dam and in no case shall the maneuverboat remain out on the dam during an ice run.

The dam shall be lowered by the maneuverboat from below unless conditions are such that it is safe to operate from above the dam, and it is desirable to break the dam by lowering from three to five wickets adjacent to the beartrap pier before actual lowering operations are commenced. The flow through the opening made by the three to five wickets adjacent to the beartrap pier may be counteracted, if necessary, by the manipulation of one or more traps in order to hold the upper pool within one foot of normal level.

The pool shall be kept below the crest of the dam in face of continued freezing temperatures. No attempt shall be made to pass ice over the dam. However, in order to meet the requirements of navigation, every effort shall be made to prevent the upper pool from falling more than one foot below the normal pool stage.

If the dam is down and there are scattered wickets partly raised due to breeching or other cause, green instead of red navigation lights shall be displayed on the lock walls to warn navigators that they must either use the lock or stop for information in regard to the exact location of these wickets before using the pass.

When the dams are lowered, the lock gates shall be open and fastened securely in their recesses, unless floating plant using the protection of the gates as an ice harbor is moored below the lock.

Flasher buoys, pass buoys, swinging pole lights, etc., shall be removed from all lock walls and piers to prevent damage during the ice periods, but they shall be replaced as soon as conditions permit, and navigation interests shall be advised of their removal or replacement immediately.

Wherever possible, the crew at each lock shall be made up of a sufficient number of trained men to carry out the work without outside assistance.

Except when contact with the District Office is not possible the pass section of the dam shall not be lowered until directions to do so have been received from the District Office. The bear-traps and movable weirs shall be lowered first and the pass wickets shall be lowered last. The procedure for lowering wickets is as follows: The back haul line from the manuever-boat shall be fastened to the lower river wall, the hatches shall be secured and all loose items of tools and equipment removed from deck. The maneuverboat shall be moved to the end of the raised wickets by using the pusher boat and hook lines. If the Bebout wickets have not automatically tripped, the maneuver-boat will be placed in position and the wickets tripped by plac-ing the wicket hook over the top of the wicket and pulling the wicket downstream. If the preceding method cannot be used, a weight or shell on the load line shall be placed on the upstream side at the top of the wicket and downstream strain placed on the load line to cause the wicket to trip. The Bebout wickets are constructed in such a manner that should they be caught stand-ing during ice periods there is only a slight possibility that they will be damaged. Therefore, in an emergency the operation of the Chanoine wickets should be given first priority. The lower-ing of the Chanoine wickets shall be accomplished, if at all possible, by fastening a hook on the end of the load line, laying the boom at a low angle over the wicket, engaging the hook on the back side of the wicket and pulling the top of the wicket upstream to disengage the prop from the hurter. Another suitable method is to use a 20-foot length of pipe, shafting or rail suspended at the upstream end by the load line and powered by the banjo line at the other end after being properly directed by the use of sheave blocks or kevels.

If ice conditions prevent the use of either of the above-methods, the wickets may be lowered by using a prop hook suspended from the load line to unseat the prop from the hurter. Cases may develop where the ice must be broken up above the wicket in order to properly position the wicket for lowering. In such

cases it may be desirable to use a weight or clamshell bucket which can also be used to hook over the back side of the wicket and unseat the prop, as outlined in the first method for lowering the Chanoine wickets. Wickets which may be left standing shall be located by number and distance from piers or river wall and reported to the District Office.

An adequate amount of manila line and a sufficient number of hooks, shall be maintained at the installation at all times. It is believed that the Lockmaster should make such equipment as hooks, pipe, or rail poles, etc., that may be required, in lieu of having them made elsewhere since he is in a better position to design or form tools that will best fit his needs. Heavy ice may cause some damage to the small oil lines and fittings of the gate and valve jack operating system at locks and dams where there are no coverplates over the pipe trenches, gate jacks and gate operating machinery. Sufficient spare fittings shall be maintained in stock that will permit immediate repairs in the event damage occurs. The cut-off valves on the oil lines at the middle of the lock land wall shall be closed when the lock is placed out of operation because of high water or ice. The valves shall be kept closed until the lock is again placed in operation. This action is to prevent excessive loss of hydraulic oil in case of failure of an oil line while out of operation.

At times when the maneuverboat is not required for dam or other operations, it shall be moved to a safe mooring and the fires shall be banked. Frequent inspections shall be made of mooring lines, ice around boat, condition of boiler, fires and water in hull.

In order to facilitate the movement of navigation while the dam is in operation, the ice forming in the approaches and around the gates shall be kept broken and the gates maintained free of ice as far as practicable by use of the maneuverboat, commercial tows, and by lockage of ice from the upper to the lower pool. Extreme care must be exercised by personnel when operating the

gates in order to prevent damage to the leaves and operating mechanism. Tows using the lock must not be permitted to rub against the gates when they cannot be properly placed in the gate recesses.

In all cases where dams are lowered because of ice conditions, all practicable warning advice and assistance will be given to navigation interests by radio and other means which are available.

2. The attached set of instructions for reporting ice conditions at the Ohio and tributary locks and dams represents data that is desired by the District Office. Ice conditions will be reported at the regular morning gage collection time and reported on ORL Form 1-1. Ice reports will be made daily upon appearance of ice in the reporting area or following a prediction of ice formation.

/s/ Larry P. Dickson
Chief, Waterways Management
Branch

1 Incl
Instructions for
Ice Reporting